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Cover: Spiny Lobster
[*Courtesy National Geographic Society, see page 292*]

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Science and Technology

(From the month's news releases; publication here does not constitute endorsement.)

Laundry Cart

A newly designed laundry cart slides on wrought iron "skis" on the edges of the steps when it is moved up or down stairs. The cart also has two large wheels in the rear and two swiveling casters in the front. The basket is made of denim and has side pockets for storage. The cart folds up to a thickness of 4 in. (Leisurehouse, Dept. SM, 110 North Lorraine St., Wichita, Kans.)

Coated paper

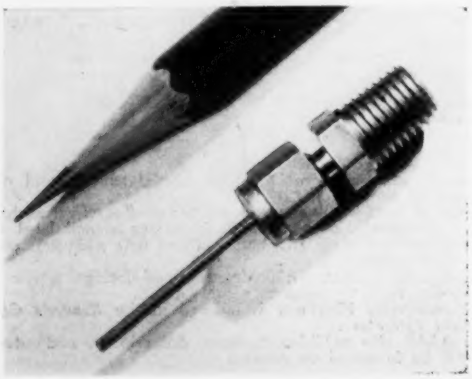
Positive prints from exposures made at $\frac{1}{2}$ sec in outdoor light can be made with a new coated paper without chemical processing. The paper is designed for making prints from photograph negatives, microfilm enlargements, or projected images. It remains insensitive to light until the coating is given a negative electrostatic charge. (Radio Corporation of America, Dept. SM, 30 Rockefeller Plaza, New York 20.)

Fathometer

A new electronic depth sounder designed for charting the bottoms of lakes, rivers, and shoal waters from very small boats has been announced by Raytheon. The new Fathometer, which weighs 40 lb, will operate for 8 hr from a 6-v storage battery. The range of the instrument is from 0 to 240 ft. The transducer is held 1 to 2 ft beneath the surface of the water; depth is recorded on chart paper that can be operated at speeds of 12, 30, and 60 in./hr. (Raytheon Manufacturing Co., Dept. SM, Waltham 54, Mass.)

Capillary Tube Fittings

Swagelok tube fittings are now available for 1/16-in. capillary tubes. These fittings are mounted without flaring the tubing; the tubing is slipped into the fitting and the nut is then turned until a tight seal is made. The fittings are made in brass, aluminum, steel, stainless steel, and Monel metal. (Crawford Fitting Co., Dept. SM, 884 E. 140 St., Cleveland 10, Ohio.)



Tool Gage

A new tool gage is designed to measure the depth of cut of a saw, dado, or jointer to an accuracy of 1/64 in. It is also useful for measuring round or irregular objects up to dimensions of $3\frac{1}{4}$ in. (Adams Products Co., Dept. SM, 119 Ann St., Hartford 3, Conn.)

Pocket Letter Scale

A new letter scale is designed to be carried in the pocket in a 3-in. leather carrying case. The scale can weigh letters up to 2 oz in weight. (Empire Lion Sales Co., Dept. SM, 1550 46 St., Brooklyn 19, N.Y.)

Bolt Sleeve

Nyltite is a new nylon sleeve that fits over a bolt and prevents shock or vibration from loosening the bolt after the nut has been tightened. The sleeves, which have been packaged in kits containing assorted sizes and lengths, also protect bolts against shearing and provide a leakproof seal. (Nyltite, Dept. SM, 2331 Morris Ave., Union, N.J.)

Camera Filter Case

Photographic filters kept in a new plastic case are visible, accessible, and shielded from dust. The combination top and filter holder for six filters fits into a cylindrical outer case that has a molded loop for attaching the case to the camera strap. When it is inserted in the case, the holder is locked in by a peg-in-slot arrangement requiring a slight turn of the top. Turning the top also seats the dust gasket. (Clarco Specialties, Dept. SM, 2037 Niles St., Bakersfield, Calif.)

Phonograph Cartridge

The ESL electrodynamic phonograph cartridge, which was exhibited at the New York Audio Fair, has a response from 20 to more than 20,000 cy/sec, less than 1 percent intermodulation distortion, minimum compliance of 4.43×10^{-6} dy/cm^2, an equivalent mass of 3 mg, and no inherent resonances within the audio range. The new cartridge is adaptable to various mountings and styluses. (Thomas F. Burroughs, Dept. SM, 306 W. 100 St., New York 25.)

Garage Floor Coating

Concrete garage floors and other surfaces that are subject to grease or oil drippings can be protected with a new coating based on Bakelite vinyl resins. Since the vinyl resins are resistant to oil and grease, the drippings do not soak into the floor, and they can be wiped up with a cloth. One pint of the coating covers approximately 40 ft^2. (National Vinyl Products, Dept. SM, 417 McArthur Ave., Redwood City, Calif.)

Syte-Ayde

Syte-Ayde is a battery-powered flashlight kit that provides light in out-of-the-way places. The kit contains four light-transmitting rods—two straight rods 3½ and 6 in. long and two of the same length, bent 90°—and three 1.5× mirrors, ½, ¾, and 1¼ in. in diameter, each supplied with a clip that fits the rod ends. All parts are stored in individual compartments of a plastic tool kit. (General Scientific Equipment Co., Dept. SM, 2700 W. Huntingdon St., Philadelphia 32, Pa.)

Basic Electronics Kit

A new basic electronics kit designed for use in school shop courses and other educational programs contains 82 components needed to perform 60 experiments illustrating electronics fundamentals. A detailed 275-page illustrated manual is included. (Crow Electri-Craft Corp., Dept. SM, 1102 Shelby St., Vincennes, Ind.)

Tennis Racket Strings

DuroLastek is a new man-made gut for stringing tennis rackets. Designed in Great Britain, the new gut is made by the spiral wrapping of nylon or terylene around a central core of nylon. The makers claim that the new fiber is impervious to damp and heat. (Dunlop Sports Co., Dept. SM, Waltham Abbey, Essex, England.)

Count Rate Meter

A new analytic count rate meter may be used with either Geiger or scintillation detectors to provide quantitative measurement of radioactivity for medical diagnoses, tracer work, process control, or surveying for contamination in laboratories. The instrument converts random counts into average counting rate and presents the average on a 4-in. panel meter that is calibrated in counts per minute. Six ranges covering any radiation intensity up to 10^5 counts/min are provided. The output of the built-in high-voltage power supply is continuously variable from 650 to 1800 v. (Nuclear Instrument and Chemical Corp., Dept. SM, 229 W. Erie St., Chicago 10, Ill.)

Spoon-and-Spatula

The Spoonula is a laboratory implement that has a stainless steel spoon at one end and a keen-edged spatula at the other. It can be used to remove powder or crystals from bottles, and to crush, scrape, and chop caked samples. (Fisher Scientific Co., Dept. SM, 717 Forbes St., Pittsburgh 19, Pa.)

Electric Generator

A new lightweight electric generator capable of 1.5-kw output is available as a temporary or emergency source of electric power. The unit is driven by a 4-cycle, direct-drive, 3-hp gasoline engine. Total weight is 107 lb. (Master Vibrator Co., 262 Stanley Ave., Dayton, Ohio.)

Glass Distinguisher

Pyrex glass can be separated from soft or quartz glass by placing the unsorted glass in a container filled with reagent-grade trichlorethylene. The soft glass is visible and the Pyrex is not, because the refractive index of the liquid is about the same as the refractive index of Pyrex glass. An earlier "distinguisher" required two liquids, carbon tetrachloride and benzene, in the proportion of 59:41. (Fisher Scientific Co., Dept. SM, 717 Forbes St., Pittsburgh 19, Pa.)

Polyethylene Jars

Polyethylene bottles and storage jars designed for handling acids and other corrosive liquids are being manufactured in 10 standard sizes with capacities ranging from 1 qt to 5 gal. Both bottles and jars are fabricated from molded and cast sections welded by the hot-gas welding process. They are light in weight and resistant to impact. The bottles have a screw cap; the jars has a friction-fitting lid. (American Agile Corp., Dept. SM, P.O. Box 168, Bedford, Ohio.)

Lubricant

Gummed, clogged, or frozen locks, hinges, and other mechanisms can be cleaned and lubricated with a new nonflammable lubricant that has low surface tension and high penetration. The lubricating component is colloidal graphite; the other components are fluorinated hydrocarbons and methyl ethylene. The lubricant is applied by placing the mouth of the container against the lock and pressing a lever with the thumb. A rubber cap directs the spray to the desired point. (John Yezbak and Co., Dept. SM, 3214 Prospect Ave., Cleveland 15, Ohio.)

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Dates of Stonehenge

V. GORDON CHILDE

Dr. Childe is professor of prehistoric European archeology and director of the Institute of Archaeology at the University of London. For a number of years he was librarian of the Royal Anthropological Institute, London, and then Abercrombie professor of prehistoric archeology at Edinburgh University. At one time he served as private secretary to the Premier of New South Wales.

THE most celebrated prehistoric monument in Europe is no doubt the complex of standing and fallen stones at Stonehenge, north of Salisbury in Wiltshire County, and recent examination has shown anew that it fully deserves this celebrity. The monument is as patently a patchwork of successive building periods as is any English cathedral; hence, it can claim no single "date," and its most astonishing features are anything but obvious at first glance.

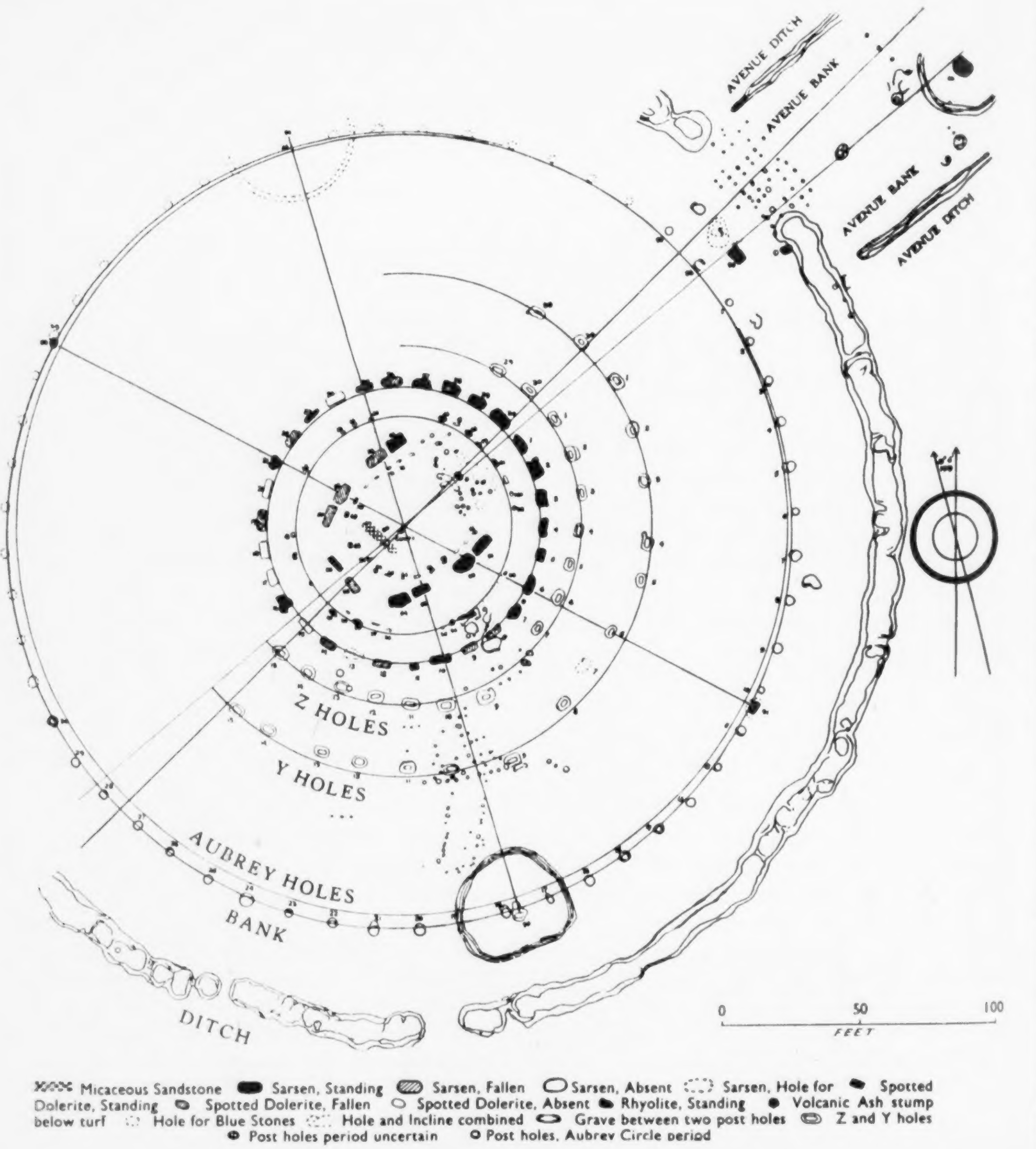
In order to understand what follows, the reader must keep in mind the following elements in the complex. Beginning from the center we may see (i) a very inconspicuous horseshoe of "bluestones"; (ii) a horseshoe of sarsen trilithons of imposing size but nearly half fallen; (iii) an irregular ring of "bluestones"; (iv) an accurate circle of sarsen trilithons; (v) and (vi) two very irregular rings of holes cut in the solid chalk, termed the Y and Z holes, but visible only after excavation; (vii) an accurate circle of similar holes, observed by John Aubrey in 1666 and now named for him; (viii) a low bank and outside it (ix) a ditch cut in the solid chalk. To the northeast in the direction of the midsummer sunrise a causeway and gap interrupt the ditch and bank, respectively. "The avenue," defined on each side by bank and ditch, runs in rather the same direction, but not in line with the causeway.

The "bluestones" (i and iii) are perhaps the biggest surprise, although they are far from imposing to look at. Geologists agree that they must have been brought from the Presely Mountains in southwest Wales, separated from the Salisbury Plain by the Bristol Channel, the Cotswold range, and a formidable tract of marshland—obstacles so serious that it seems most likely that the stones were brought by sea around Land's End to the mouth of the Avon, a little west of Southampton! Although sarsen (the stone used in ii and iv) does occur naturally in the county, large blocks, comparable in size to the Stonehenge monoliths, are to be found today only on Marlborough Downs near Avebury, some 40 miles north of Stonehenge and separated from it by the marshy vale of Pusey (*1*).

Each trilithon is composed of two tall uprights or orthostats that together support a horizontal lintel. The underside of the lintel is provided with mortise holes into which fit tenons projecting from the tops of the uprights—surely a carpenter's device translated into stone! Most striking of all, the lintels of the horseshoe (ii) are wider at the top than below. This dressing has the effect of compensating for the perspective foreshortening that would otherwise distort their symmetry when viewed from the ground. Now, this architectural device is not known anywhere else before the classical period of Greek architecture. If then Stone-

henge were built before 500 B.C., it will offer the oldest instance of the application of this optical principle.

But was it? To date the composite monument, we must distinguish what is to be dated. For a quarter of a century it has been known that two structural periods can be recognized from the plan alone. The accurate Aubrey circle must have been laid out by stringing from its center before the sarsens were set up, and its center differs by some 4 feet from that of the trilithon circle (iv). Hence, the Aubrey circle, together with the bank and ditch and probably also the heelstone, in the avenue, (extreme upper right corner of the map) may be termed Stonehenge I. Stonehenge II will then comprise the trilithon circle and horseshoe, (iv) and (ii), and the avenue. The bluestones were surely not set in their present positions before the erection of the sarsens that prevent the bluestone circle from being strung out from the center and so account for its irregularities. But two of the now fallen bluestone uprights bear on one face mortise holes similar to those in the sarsen lintels, while from a third projects a tenon (*1*). Hence,



General plan of Stonehenge. [Reproduced from *Antiquity*]

these very sacred stones, brought so laboriously from Wales, must once have formed part of a "Bluestonehenge," similar at least in its carpentry structure to Stonehenge II. Where Bluestonehenge originally stood is a matter of conjecture. Perhaps in South Wales. But bluestone chips found in the ditch of the Cursus suggested to J. F. S. Stone (*2*) that it may have stood at the western end of that monument, ¾ mile northwest of Stonehenge, while excavations in 1953 gave R. J. C. Atkinson (*3*) grounds for thinking that the Y and Z holes were originally designed to receive the bluestones.

Of course, the builders of Stonehenge II could not inscribe on the uprights, "Erected in 1453 B.C.," if only because they could not write. But they did something almost as good; they hammered out on the faces of several sarsen uprights representations of bronze axheads that can be dated in terms of the archeological periods into which British prehistory has been divided. The first ax figure was noticed accidentally in July 1953 by Atkinson (*4*) while he was photographing a 17th-century inscription. Thereafter, he and others recognized more than 45 others. Once pointed out, most figures are unmistakable. Yet, although hundreds of antiquaries since 1666 have minutely scrutinized the stones and tourists have scratched their names thereon, no one before saw a single ax!

Axheads, just like those represented on the trilithons, are found in the rich barrows of the Wessex culture which serve to define a distinct period within the Bronze Age of southern England. The newly discovered figures thus confirm the attribution of Stonehenge II to the Wessex culture, suggested by Stuart Piggott in 1950 from the concentration of typical barrows around the sanctuary. But the Wessex culture can be dated rather closely in terms of the historical chronology, based on the written records of Egypt and Hither Asia. Surprising though it may be, not only have beads of fayence made in eastern Mediterranean lands been found in several Wessex graves, but also ornaments of gold and amber, fashionable in Britain at that period, have been recognized in Mycenaean tombs in Greece and Crete that can be dated between 1500 and 1400 B.C. By that time the Wessex culture was already flourishing in England.

That Stonehenge was set up by then is more directly indicated by another figure carved on a trilithon. This represents a bronze dagger, but not apparently of any of the familiar British types; it looks more like a Mycenaean weapon of the period 1550–1500 B.C. Admittedly, no such Mycenaean dagger has yet been found in Britain or anywhere this side of the Alps. But a dagger, certainly manufactured in, and imported from, Mycenaean

Stonehenge, showing tenon on trilithon of horseshoe from which lintel has fallen. (Right) Sculptured trilithons of horseshoe intact; (center) standing bluestones with intact arc of trilithon circle behind; (left) sarsens of horseshoe.

Greece, albeit of a later type current from 1350 to 1150 B.C., was in fact dug up from a barrow at Pelynt near the Cornish coast more than a century ago and had lain unnoticed in the Truro Museum ever since, until I recognized it in 1948 (*5*). So trade did really bring the illiterate barbarians of remote Britain serviceable weapons as well as trinkets from the workshops of the civilized Aegean area.

Stonehenge II can thus be dated between 1550 and 1450 B.C. or, in archeological terms, to British Early Bronze Age 2. At that time an aristocracy rich in flocks and herds, in meat, dairy produce, hides, and wool dominated the chalk downs of southern England from Eastbourne to Weymouth and the tin lodes of Cornwall and controlled cross-country routes from Ireland and Wales to the Channel. It was an appropriate juncture for the construction of a sanctuary of exceptional dignity and perhaps for the incorporation therein of the materials of another of even more ancient sanctity, if not for the actual transportation of the bluestones from South Wales.

But the site selected was itself already sanctified by ancient tradition. Stonehenge I, too, can be dated in archeological terms: it turns out to be "Neolithic" or, more precisely, "Secondary Neolithic." In plan and function, it conforms to a now well-recognized class of circular earthworks, very unhappily termed "henges" and best known from a group described and excavated by Atkinson at Dorchester on the Thames near Oxford. These monuments prove to be cremation cemeteries and consistently yield flint implements, stone ax- and maceheads, pins, and other relics of "Secondary Neolithic" type, such as had been recovered from Shonehenge I during the 1920–26 excavations (*6*).

Ax and dagger figured on trilithon. [Courtesy R. J. C. Atkinson]

Moreover, examination of charcoal from one of the Aubrey holes by W. F. Libby gave a "radiocarbon date" of about 1850 B.C. for Stonehenge I (*7*). Now, this is the traditional "date" for the arrival in Britain of round-headed invaders, termed conventionally "the beaker folk." But in their graves under round barrows are found the first bronze weapons and ornaments used in Britain. So their invasion is rightly taken as marking the beginning of the British Early Bronze Age. If this be correct, the radiocarbon date would seem to conflict with the attribution of Stonehenge I to the Neolithic Age.

The contradiction, however, is at worst terminological. Neolithic and Bronze Age do not stand for empty stretches of mathematical time, but for periods during which there flourished in the British Isles cultures (that is, recurrent assemblages of archeological types) characterized by subsistence farming but also by the absence or presence, respectively, of metal weapons and tools.

Now the British "Neolithic" comprises several distinct cultures. It began with an actual infiltration of peasants who introduced cereals and the technique for their cultivation and probably sheep and cows, too. They dug the causewayed camps of southern England, buried their dead collectively under long barrows or in megalithic family vaults under long cairns, made "leathery" round-bottomed pots (Neolithic A ware) and leaf-shaped flint arrowheads. How many bands of such immigrants can usefully be distinguished is still an open question. All seem to have come immediately from some parts of France, and taken together their fossilized behavior has produced what has come to be called the Primary Neolithic culture or cultures.

Over against them stand four or more Secondary Neolithic cultures (*8*). All exhibit traits that may be derived from autochthonous Mesolithic cultures. They are called "Secondary Neolithic" on the assumption that their authors were in fact such native food-gatherers who had adopted from the immigrants food production—that is, corn and sheep—and perhaps such neolithic arts as potting. But their pottery is quite unlike Primary Neolithic or Neolithic A ware in technique, form, and ornamentation. In fact, several distinct kinds of Secondary Neolithic pottery are distinguishable and serve to symbolize as many distinct cultures, although precisely what Secondary Neolithic artifacts are exclusively associated with any one of the cultures thus defined remains uncertain.

We may distinguish the Ebbsfleet (B1)-Peterborough (B2) series. Ebbsfleet ware has been found in a causewayed camp near Eastbourne and in a henge at Dorchester, but its stratigraphic relationship to Neolithic A and beakers remains rather vague. Peterborough pottery, although found in several long barrows and in the ditches of causewayed camps, always appears later than the earliest Neolithic A and generally associated with beakers. Rinyo-Clacton (C) ware is best known from the celebrated neolithic villages of Skara Brae and Rinyo in the Orkney Islands, where it seems mostly later than the local Neolithic A but earlier than the arrival of beakers on the islands, and from Woodhenge near Stonehenge. Wares from a neolithic house and cremation cemetery on the Isle of

Man and others from dwellings at Knockadoon near Lough Gur in County Limerick, Eire, are likewise classed as Secondary Neolithic but have not been proved stratigraphically to precede the beaker invasions.

Indeed, there is so much overlap between Secondary Neolithic and beaker cultures that some authorities propose to adopt the desperate expedient of labeling beakers "Neolithic" too. But bronze objects have been found in beaker graves, albeit in a very low percentage of the total known. Moreover, the systematic petrologic study of stone axheads recently conducted (*9*) has established that the exploitation of ax factories at Great Langdale in the English Lake District and at Penmaen Mawr in northwest Wales and the distribution of their products as far afield as southern England, Scotland, and western Eire were due to Secondary Neolithic, especially Neolithic B, communities. It can be argued that the extensive and comparatively regular "trade" thus attested is not only the precondition for, but also a criterion of, the Bronze Age.

The latter argument is, however, not really a valid objection to terming the British cultures just considered "Neolithic." For the dwelling place or Grubkeramisk cultures of Scandinavia are classically "neolithic" but "secondary" in the sense that they are largely derived from local Mesolithic cultures and contrasting and overlapping in time with that of "Primary Neolithic" immigrant farmers whose advent is reflected in the botanical, as well as the archeological, record. Yet C. J. Becker (*10*) has shown that it was precisely these "Secondary Neolithic" folk who were largely responsible for the exploitation of the rich flint deposits of Denmark and southern Sweden and for the trade in flint axes that penetrated far into northern Sweden. Now the Scandinavian Secondary Neolithic pit-ornamented pottery is absurdly like British Ebbsfleet Neolithic B ware.

Even if this similarity denotes no direct relationship, the British Neolithic culture thus defined is ultimately a parallel offshoot of the Mesolithic "Maglemosean" that extended all over the great north European plain from the Pennines in England to the Urals in Russia before the inundation of the North Sea basin. The trade in axes that subsequently developed on both sides of that sea can be regarded in each case as a continuation and development of older behavior patterns without invoking the influence of any invaders from outside.

In the British Isles, the beaker folk did not introduce the arts of metallurgy, since their graves are rare and late in Cornwall and Eire, the chief producing centers. As warriors, they did provide

Trilithon of horseshoe with erect bluestone in front of it (left). Modern Druids performing equinoctial rites.

the first reliable local market for metalware and thus initiated the British Bronze Age. But they have left no trace on Stonehenge I, although beaker burials are connected, perhaps secondarily, with the rival sanctuary at Avebury in North Wiltshire. Accordingly, Stonehenge I remains truly "Neolithic" even if its construction does not antedate the first arrivals of beaker folk in other parts of England and of metallurgists (from Spain?) in Cornwall and Eire.

References and Notes

1. S. Piggott, "Stonehenge reviewed," in *Aspects of Archaeology*, W. F. Grimes, Ed. (H. W. Edwards, London, 1951), pp. 274–292.
2. J. F. S. Stone, *Archaeol. J.* **104**, 7ff. (1948).
3. R. J. C. Atkinson, *Nature* **172**, 475 (1953).
4. ———, "The date of Stonehenge," *Proc. Prehistoric Soc.* **18**, 236 (1952). I must thank R. J. C. Atkinson for generously allowing me to reproduce here his photograph of the dagger.
5. V. G. Childe, *ibid.*, **17**, 95.
6. R. J. C. Atkinson *et al.*, *Excavations at Dorchester, Oxon, Oxford*, Ashmolean Museum (1951).
7. R. J. C. Atkinson, S. Piggott, J. F. S. Stone, *Antiquaries J.* **32**, 14 (1952). I. W. Cornwall [*Discovery* **14**, 276 (1953)] points out that this date agrees disconcertingly with Norman Lockyer's astronomical date for Stonehenge I. The latter date may, however, be safely ignored as worthless for reasons expounded by Trotter in "Stonehenge as an astronomical instrument," *Antiquity* **1**, 42 (1927); it may just as well have been oriented to the midwinter sunset as to the midsummer sunrise [R. S. Newall, *Man* **53**, No. 228, 144 (1953)].
8. The term was first used and explained by R. J. C. Atkinson (*6*) whose account is summarized here.
9. J. F. S. Stone and F. S. Wallis, "Third report on the petrological determination of stone axes," *Proc. Prehistoric Soc.* **17**, 99 (1951).
10. C. J. Becker, "Die nordschwedischen Flintdepots," *Acta Archaeol.* **23**, (1952); see also "Den Grubekeramisk kultur i Danmark," *Aarbogen f.n.O.o.H*, Copenhagen, (1950).

Recent Biological Studies on *Teredo*—A Marine Wood-boring Mollusc

CHARLES E. LANE

For the past 5 years, Dr. Lane has been associate professor of marine biology and research associate in the Marine Laboratory of the University of Miami, Coral Gables, Florida. After receiving his doctorate in zoology from the University of Wisconsin, he taught at the University of Wichita. During World War II he served as an aviation physiologist with the Air Force and later became a research biochemist with the Borden Co.

MOLLUSCAN WOOD BORERS included within the family Teredinidae cause millions of dollars' worth of property damage each year according to official U.S. Navy estimates. Their ravages have been familiar to human observers at least since the time of Aristotle. Indeed, man has probably been forced to contend with these rapacious destroyers of wooden structures since his first primitive raft was launched in some prehistoric bay or estuary.

Teredo is a genus of cosmopolitan distribution. Even though marine borers are popularly considered to be restricted to tropical and subtropical seas, they have been collected and identified (*1*) in the Atlantic Ocean from Argentia, Newfoundland in the north to Coco Solo in the Canal Zone. They have also been collected at various times from all the main island groups of the North Atlantic. Infection has been reported in the Pacific from Balboa in the Canal Zone to Kodiak, Alaska. Most of the larger islands of the Pacific have reported infestation with marine borers at various times in the recent past.

Individual species show considerable variation in adult size. The forms that are found in the Miami region are generally not more than 150 mm in length and rarely exceed 8 mm in diameter. *Teredo* infestation is generally either massive or nonexistent in our experience. It is, for example, not unusual to find evidence that several thousand larvae have penetrated a standard exposure panel with a total surface of only 130 in.^{2} during a single 30-day exposure period. In one annual peak of infection 7102 larval borers were counted in a single exposure panel.

Teredine borers spend their entire adult life encased in wood. The borer can grow only by lengthening its burrow. This is accomplished by the rasping action of a pair of modified bivalve shells equipped with many rows of tiny calcareous teeth. These shells are powered by the adductor muscle which is typical of other bivalves. The animal fills the burrow completely. The outer layer of the mantle is in close contact with the wooden wall of the burrow. The mantle secretes a calcareous layer, reminiscent of the nacreous layer of the shell of other pelecypods, which forms the innermost lining of the burrow. It is this calcareous layer which delimits the burrow in the x-ray image (Fig. 1). Since the burrow is fully occupied by the animal, there is no way of eliminating wood debris scraped from the advancing face of the burrow except to pass it through the digestive system of *Teredo*. The gut of adult borers is typicaliy filled with finely comminuted wood fragments in transit.

A group of investigators, including Clapp, Edmondsen, Bartsch, Richards, Turner, and others, has compiled an impressive body of information concerning the distribution, ecology, anatomy, and taxonomy of the marine borers as a group. With the conspicuous exception of two stimulating studies (*2*) and (*3*) completed more than 25 years ago, there has been little recent investigation of the general biology, physiology, and biochemistry of this group of animals. Studies conducted in this laboratory during the past 5 years have been directed toward explaining, in some detail, certain aspects of the relationship between the borer and its environment as well as some phases of its general physiology. The purpose of this paper (*4*) is to summarize some of the results of these studies.

Development and life-history. The genus *Teredo*

may be considered to be typical of the family. At least three species have been reported to inhabit local waters (*5*). The presence of the organisms in wood is signalized by the appearance of numerous tubelike siphons extending from the surface when the water is quiet and the wood is undisturbed. The siphons in narcotized, relaxed living specimens are about 250μ in diameter by 15 to 25 mm long. Infection is indicated in wood that has been removed from water by the existence of a multitude of tiny holes from 0.50 to 1.0 mm in diameter. These are the original points of entrance of the shipworm larvae. By the time the borer has metamorphosed into the adult, this entrance hole is occupied by the two siphons. These structures have both longitudinal and circular muscle elements in their tenuous walls. The contraction of the longitudinal muscles shortens the siphon and may effect a complete retraction of the siphon into the burrow.

In their pallet mechanism, teredinids possess a device to effect complete closure of the burrow. The pallet is typically a calcareous structure with a stalk and an expanded distal blade. The stalk is imbedded in a pallet-sac and serves as the point of insertion of a series of muscles that move the pallet. The flattened distal blade completes the closure of the burrow by uniting with its fellow to produce a cone-shaped plug which can be pulled snugly into the external orifice of the burrow. In borers such as *Bankia,* whose pallets resemble stalks of barley, closure is apparently effected by interdigitation of the terminal portions of both pallets. If the wood in which the borer is living is removed from the water, or if it is placed in a medium of significantly different salinity, temperature, or oxygen content, then the siphons are retracted and the entrance to the burrow is closed securely by the pallets. This mechanism is also employed to prevent the entrance into the mantle cavity of environmental materials which might be noxious to *Teredo.* It might be mentioned, in passing, that studies currently in progress in our laboratory confirm the observation made by others (*6*) that *Teredo* can survive a considerable period of closure of the burrow. If the infected panel is removed from the water and placed on a shelf in the laboratory for a week or more, a majority of the animals resident in the panel will still be alive. Moreover, by means of x-ray studies, it can be shown that boring will have continued in certain of the burrows during the time that the panel was exposed to air.

Fertilization occurs when spermatozoa, shed into the water through the excurrent siphon of a male animal, enter the mantle cavity of the female in the respiratory stream (*7*). Since infection is generally heavy, and since it tends to be confined to susceptible areas of the wood, there is frequently a considerable local concentration of siphons. This may be considered to increase the likelihood that spermatozoa shed into the slow-moving film of water immediately adjacent to the surface of the wood will be aspirated into the mantle cavity of a female. In local species cleavage is evidently very rapid. It is possible that insemination may be associated with interference with the normal respiratory stream; or that the spermatozoa themselves or fluids associated with them may cause retraction of the siphons and closure of the burrow. Whatever the mechanism is, the fertilized ovum is retained in the maternal mantle cavity during early cleavage and then "implants" itself in the substance of the gill. Here the early developmental stages are completed. The organism is liberated from the mater-

Fig. 1. A portion of a full-sized x-ray of a standard collecting panel. The lower and left-hand borders are the edges of the panel. Exposed in Biscayne Bay for 13 wk.

nal gill in the veliger stage. At this time it commences its very brief, infective, free-living larval life.

Other species of *Teredo* possess a planktonic larval stage which may be of considerable duration (*8, 9*). Local species, however, show a definitely restricted larval period. We have found (*10*) that larvae denied access to wood invariably die within 2 wk. Indeed, after about 4 days such larvae can be shown to have lost the ability to penetrate wood successfully. During the period of approximately 96 hr in which the larvae are infective, they pass through quite marked morphological, as well as physiological, changes. During the first 24 hr the animal swims actively by means of velar cilia. The velum has been likened (*11*) to the rotor of a helicopter, since it produces such a wide variety of directions of motion. Swimming of the larva is largely at random, although there appears to be a tendency for movement to occur in the vertical plane preferentially. Observed swimming rates suggest that peak short-term velocity may approximate 7 mm/sec. There appears to be some tendency for the animals to respond to illumination. The shells, which at this stage of development consist entirely of chitin, do not contribute to swimming, nor does the muscular foot appear to participate in this activity. Manifestly the dissemination of such infective larvae must be accomplished largely by water currents.

During this first 24 hr of free-living existence, there is an increase in the rate of oxygen consumption (Fig. 2). This increase may be the result of increased ciliary activity or it may be permitted by the maturation of glycolytic enzyme systems which allow the completion of oxidative glycolysis. It has been shown (*12*) that the large endowment of glycogen, with which the zygote begins its existence, is largely expended by the time the larva has penetrated the wood that is to constitute its definitive environment.

Beginning about 24 hr after its release from the maternal mantle cavity, there is a profound change in the behavior of the larva. It is no longer predominantly a swimming animal, by which activity it has generally remained in the surface layers of the water, but it now becomes a characteristic crawling form. It settles to the bottom of a container in which it may be kept, and presumably also to the bottom of the water column in which it lives in nature, and crawls actively over the substratum by means of its muscular foot. This organ may be 3 times as long as the total diameter of the larva. Crawling is accomplished by extending the foot to its full extent, fastening the tip to the substrate, then contracting the entire foot to bring

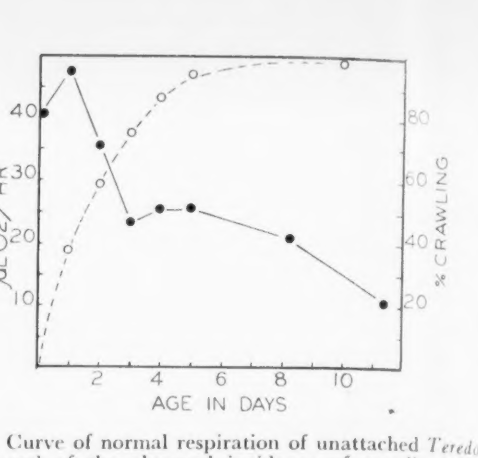


Fig. 2. Curve of normal respiration of unattached *Teredo* larvae and of the observed incidence of crawling in a series of laboratory cultures. Larvae that do not crawl progress by swimming. Redrawn from references 10 and 11.

root and tip in close apposition. This produces a lurching locomotor pattern that is reminiscent of the larvae of geometrid moths.

In addition to its obvious utility as a locomotor organ, the foot is also a sensory organ of some importance. It can be observed to engage in a regular search pattern, probing and prospecting each surface irregularity and depression. Larvae have frequently been observed to begin the complex of reactions that usually result in penetration of wood at one point, pause, abandon this location, and move off to seek another. There appears to be a definite preference for spring wood as a point of initial entrance.

Between 24 and 48 hr of free-living age, the larval teredid, if it is to survive, has selected a satisfactory locus for penetration of the wood. We have shown (*11*) that the wood must be properly conditioned for penetration. This conditioning involves saturation with water and, probably also, the development of a suitable microflora and fauna. The lignins and other materials that bind the cellulose fibers of the wood together must be so modified that the larva is able to insinuate itself into the substance of the wood. At this time the shell is still composed of uncalcified chitin and has not yet developed the teeth which make the shell of the adult borer such an effective wood rasp.

The process of penetration has been observed frequently under the microscope. The shells are rocked rhythmically back and forth in a rough scraping movement. The foot, meanwhile, is also industriously sweeping the surface of the spot where penetration is to occur. In a short time a small heap of debris is cleared from beneath the shells by the foot. This accumulates as a conical pile within which the larva may still be observed to move. If the debris is removed at this stage it is

quickly replaced. If the animal remains undisturbed this heap of rubble becomes involved in a general and rapid calcification process. During this period, which lasts only a few hours, the shells become calcified, teeth begin to appear for the first time on the shells, and the initial pile of debris becomes cemented together to form the "calcareous cone" that is pathognomonic of early *Teredo* infection. Very shortly after this the animal becomes completely buried in the wood that is to constitute its shelter throughout the balance of its adult life.

Detailed study of individual borers in exposure panels, by means of weekly x-ray examination, has shown that the average duration of adult life in these waters is only 10 wk. This life-expectancy does not appear to be significantly influenced by temperature, salinity, or other common ecologic factors. Population density influences the duration of adult life more than any other single factor.

General biology. Even cursory examination of x-ray photographs of infected wood panels (Fig. 1) reveals that *Teredo* burrows never intercommunicate, nor do they ever break out through the surface of the panel. As long as the borer is alive, the burrow is extended by approximately its diameter each week. If the burrow approaches another too closely or comes close to the edge of the panel, then it is turned through approximately 90°. If, in the new direction, further obstacles are encountered, they are surmounted by still further changes in direction. Frequently a borer is seen thus to blunder into a cul-de-sac from which there is no escape. When this occurs the standard procedure appears to be to develop a calcareous rounded cap over the anterior end of the borer. This seals off the burrow and effectively terminates growth and continued life of the animal. Manifestly this occurs with greater frequency when the infestation is heavy than when only a small number of borers is present.

As adults, marine borers live encased within a wooden matrix; contact with the aquatic environment is maintained only through a pair of siphons. If it is to be used as food, suspended particulate organic material must be extracted from the stream of water that is pumped through the siphons. The oxygen requirements of the animal are satisfied by extracting dissolved oxygen from this identical stream of water. Similarly, this siphonal stream is responsible for the removal of undigested and indigestible food material from the burrow as well as for the final elimination of soluble wastes produced by the normal metabolism of the animal. For all of these reasons it was of interest to us to determine the magnitude and the mechanics of the circulation of water through the mantle.

This function has been measured directly in an apparatus similar to that shown schematically in Fig. 3 (*13*). Results obtained by the use of this device indicate that the average borer circulates between 10 and 20 ml of water an hour through the mantle cavity. This range expresses merely the general order of magnitude. The precise volume of the ventilation stream varies widely from minute to minute in the same animal. In this same apparatus we also studied the ability of the ciliary mechanism to circulate water against a hydrostatic head of pressure. The pressure difference represented by 5-mm difference in the water levels caused almost complete cessation of circulation. When the pressure difference was removed there was an abrupt, dramatic increase in the circulation rate, which even exceeded 100 ml/hr for brief periods. This observation should be considered in relation to an earlier statement (*14*) that the maximum positive pressure recorded within the mantle cavity was only 7 mm of water.

Additional information regarding the magnitude of the ventilation current through the mantle may be obtained by study of the oxygen consumption of adult *Teredo in situ*. If it is assumed that a constant proportion of dissolved oxygen is extracted in each passage over the gills, if the gas content of the water is known, and if the total oxygen removed from the medium can be measured, then all the ingredients are at hand out of which to construct an indirect approximation of pumping rate. Study of many individual adults has defined the range of normal oxygen consumption for the local population under standard conditions of measurement. This spread is from 5 to 30 mm^3/hr for each animal. If it is assumed that the

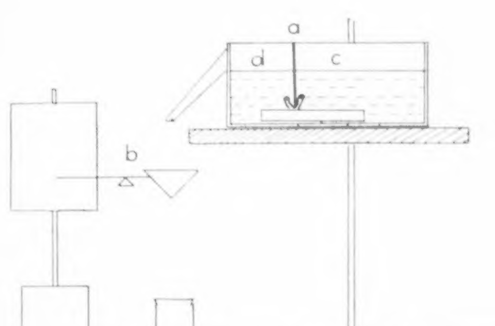


Fig. 3. Schematic diagram of apparatus employed to study pumping rate. Septum (*a*) completely divides the incurrent chamber (*c*) and the afferent siphon from the excurrent chamber (*d*) and the contained efferent siphon. A recording drop-counting apparatus (*b*). Water is pumped by the animal from (*c*) through the mantle cavity into chamber (*d*) where it displaces an equal volume into the drop-counting assembly.

water is saturated at the temperature of the observation, then it becomes comparatively easy to calculate the amount of water that must have been circulated to satisfy the measured oxygen consumption. These two different methods produce figures for the total pumping rate that are within 10 percent of complete agreement.

In our studies of oxygen consumption (*14*) it was found, in fact, that oxygen consumption, although of significant magnitude, was rarely constant in amount. The rate curves showed cyclic variations. These suggest the existence of a poorly developed or relatively inefficient respiratory control mechanism. This mechanism is currently being investigated in this laboratory from the point of view of both its morphological basis and the nature of its physiological sensitivity.

The ability of the animal to extend its burrow also depends upon the existence of the cilia-induced respiratory current and upon the positive intramantle pressure associated with it. It must be remembered that *Teredo* is devoid of any internal skeletal structures. The flaccid animal is actually adherent to the wall of the burrow only at its posterior extremity. If the boring shells are to maintain contact with the advancing face of the burrow, some internal mechanism must be developed to insure this apposition. The production and maintenance of turgor is the result of the interaction of siphonal musculature and the activity of the cilia of the gill and the mantle.

The siphons contain both longitudinal and circular muscle fibers. The latter serve a sphincteric function. In the living animal the siphons may be observed to display true peristaltic and antiperistaltic waves. The coordination of the siphonal muscles and the cilia of the mantle and the gills regulates the volume of the ventilation stream and the magnitude of the intramantle pressure. If the circular muscles contract to restrict the volume of the excurrent flow and if, at the same time, the cilia continue to propel their wonted volume of water, it is apparent that the intramantle pressure will be increased up to a limiting value. If, on the other hand, the incurrent and the excurrent siphons simultaneously are occluded by contraction of their sphincters, and if the longitudinal muscles then contract further to decrease the volume and increase the pressure within this closed system, a "cough reflex" is established by which considerable propulsive force may be generated. It is not unusual to observe fecal pellets shooting for several inches out of the suddenly relaxed excurrent siphon. This may be considered to be another expression of the reality and of the magnitude of intramantle pressure.

We have described (*14*) the direct cannulation of the mantle cavity of normal *Teredo* in place in wood. A sensitive water manometer was employed to record pressure changes during prolonged periods of observation. It was noticed that the intramantle pressure showed cyclic changes in value. These cycles were of approximately the same duration (about 11 min average at 25°C) as the cyclic peaks in the curves of oxygen consumption. It is reasonable to infer that there is a causal relationship between these phenomena and that they are both due to the operation of a single stimulus, that of oxygen deficiency.

All members of the family Teredinidae live in wood. The morphology of the animal and its relation to the burrow demand that all wood removed by the shells in growth be passed to the outside by way of the digestive system. Harrington (*2*) and Boynton and Miller (*3*) early suggested the possibility that *Teredo* possesses a true cellulase enzyme system. Against this background of speculation and fact it was determined to begin the intensive study of the carbohydrate metabolism of these organisms.

It was first shown (*15*) that adult borers may contain up to 50 percent of their dry weight as glycogen. We then investigated (*16*) the cellulase enzyme complex associated with the gut. The total cellulose-splitting capacity of the shipworm was shown to be the result of the activity of at least two enzyme systems that differ in their *p*H optima, their rate of hydrolysis, and their site of formation in the gut. The anterior, "prececal" portion of the gut is characterized by the presence of a series of glandular and other evaginations which have been collectively described as the "liver" (*9*). *On a priori* grounds it might be anticipated that this portion of the gut would elaborate most of the digestive enzymes and, perhaps, account for a significant share of the total absorption from the digestive tract. It was found, on the contrary, that the total enzyme content and the activity of the enzyme system itself in this segment of the gut are only about half that of the enzyme elaborated by the comparatively simple postcecal gut. The enzyme appears to be considerably more active, *in vitro*, when it is provided with trace amounts of adenosine triphosphate. In common with the cellulases of many fungi and other microorganisms (*17*), the cellulase of *Teredo* shows a *p*H optimum on the acid side of neutrality. It might be mentioned, in passing, that the total cellulase of *Teredo* exceeds that of the crustacean borer *Limnoria,* described by Ray and Julian (*18*) by several hundred times.

Unpublished observations made in our laboratory indicate that the free-swimming larva of

Teredo possesses considerable concentrations of cellulase enzyme. It was also observed that much of this activity persists in larvae that had been dried in vacuum at 50°C. Manifestly the possibility exists that this enzyme system in the larva may significantly facilitate initial penetration of the wood.

Since *Teredo* inhabits a matrix that consists predominantly of carbohydrate, since its adult life is spent rasping away this matrix and passing the comminuted fragments through the digestive system, and since the organism has been shown to possess an enzyme armament capable of converting this matrix carbohydrate into glucose, the conclusion is clear that *Teredo* possesses an active and capable carbohydrate metabolism. That a carbohydrate resulting from cellulose breakdown can be converted to glycogen is clear from the very high concentrations of this substance found in the adult. The question naturally arises whether wood alone constitutes an adequate diet, or whether other, supplementary substances are also required by *Teredo*.

We have investigated this aspect of the problem (*19*). It was first established that the total protein content of the adult borer is very low, only a few percent on a dry basis. Hydrolysis of the shipworm to resolve these proteins into their component amino acids, and subsequent qualitative chromatographic analysis of the hydrolyzate revealed that the proteins are comparatively simple. When it was tested against 22 known amino acids, the shipworm hydrolyzate was positive for only 8 (Fig. 4). Simultaneous hydrolysis of uninfected portions of the panel and subsequent similar analysis showed that the wood contained, and presumably had contributed, only half of the amino acids proved to be present in the borer.

At this point in the investigation it was recalled that adult *Teredo, in situ* in small blocks, maintained in open test tubes of sea water, survived in the laboratory for long periods of time. As long as the borer was alive the water remained sparkling and clear. When the borer died, the water in the tube became murky from the presence in it of myriads of microorganisms. Apparently, during life, *Teredo* removes suspended particulate material of appropriate dimensions from the water of the respiratory stream. This observation suggests that teredids, in nature, may profit from the occurrence of nannoplankton organisms in their aqueous medium. To test this possibility a quantity of sea water was first filtered through a plankton net of appropriate mesh to remove the organisms that were patently unfit, because of size, to serve as food for *Teredo*. The filtrate from the net was then further filtered through a finer-meshed asbestos mat. The cake and entrapped nannoplankton were then hydrolyzed. The hydrolyzate was shown to contain all but one of the amino acids shown to be present in *Teredo* but to be absent from the wood in which the borer was living. The sole amino acid not accounted for in this way was phenylalanine. The possibility of interconversion between phenylalanine and tyrosine must not be overlooked.

Thus, from the standpoint of its food, it appears that *Teredo* uses wood as the primary source of carbohydrate for energy and for immediate metabolism. Wood also contributes certain of the amino acids required by the borers. However, to complete the amino acid pattern typical of the animal, another protein source must be available. It now appears that this accessory source of protein most readily available to *Teredo* is the nannoplankton of the coastal waters in which it lives.

Summary. The studies reported here present a coherent, but still unfinished, portrait of one marine invertebrate in relation to a rather highly specialized environment. *Teredo* derives both protection and nutrition from the wood in which it lives. A high level of dietary cellulose is associated with a complex of enzymes able to hydrolyze cellulose. The effectiveness of the cellulase system and the functional capacity of enzymes concerned in

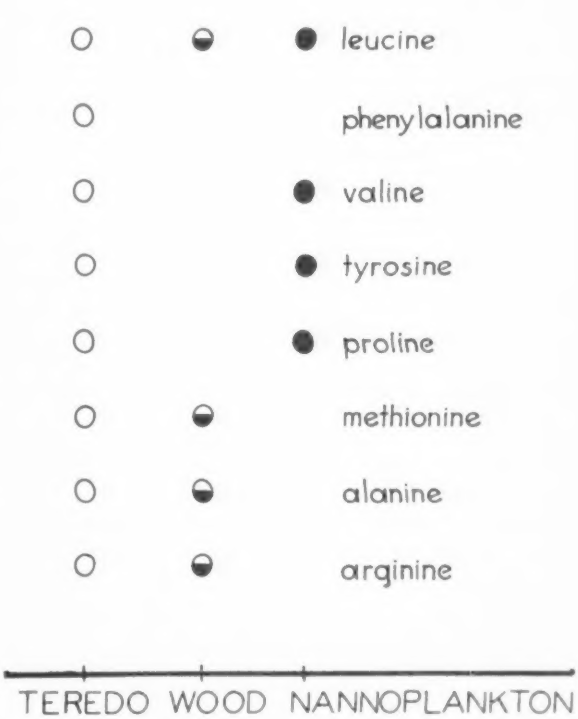


Fig. 4. Amino acid composition of adult *Teredo*, of the wood in which it lives, and of nannoplankton collected from local sea water.

glycogenesis are demonstrated by an extremely high normal glycogen content. The high level of storage carbohydrate coupled with a well-developed mechanism for anaerobic glycolysis helps to explain the ability of the animal to survive adverse environmental conditions. This survival is accomplished by closing the burrow and sealing it off from the outside world with the pallets.

The existence of a coordinated mechanism to produce a circulation of water through the mantle cavity insures satisfaction of the oxygen requirements of the animal. This ventilation current is also employed to introduce accessory food materials, to discharge soluble and insoluble waste materials, and to secure dissemination of viable larvae. The phenomenon of mantle circulation has important secondary effects. Chief among these is the maintenance of an internal turgor without which boring would be impossible.

The reproductive behavior of local species of *Teredo* shows some significant deviations from that of other pelecypods. The larvae are retained in the maternal organism throughout early development. They are released only as self-sufficient free-living veligers.

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Spiny Lobster

The life story of a lobster that leaves home as an infant is being unfolded by marine science. The tiny lobster shown on the cover was found in the Gulf Stream plankton surveyed by a National Geographic Society-University of Miami scientific expedition. These lobsters may travel hundreds of miles from the place they are spawned to the sea bottom where they grow to maturity. The scientists believe that these lobsterlings may have come from waters around the West Indies, far to the south. Fine-mesh nets towed by the research ship at varying depths have regularly brought up long-legged spiderlike offspring of the spiny lobster. Most unlobsterlike at this stage of development, these creatures are transparent—so glass-clear that all but their pigmented eyes disappear when submerged. The photograph shows the baby lobster greatly magnified under a microscope.

Ages at Time of First Election of Presidents of Professional Organizations

HARVEY C. LEHMAN

Dr. Lehman is professor of psychology at Ohio University, where he has been teaching since 1927. He received his training at the University of Kansas and the University of Chicago. He has taught at Hibbing Junior College, Minnesota, and the University of Kansas. Dr. Lehman's earlier research concerned the psychology of play and recreation. More recently he has made studies of men's creative achievement in relation to chronological age.

MOST members of any professional organization would probably agree that the president of their organization is not elected just to honor him for his outstanding professional accomplishments. Nevertheless, such election is usually considered to be one of the highest professional honors. Indeed, to many potential aspirants, election to the presidency of one's professional society is clear evidence that the one thus honored has reached the top, or almost the top, of his profession.

This article sets forth the chronological ages at which individuals have *first* been elected presidents of well-known national learned, scientific, and technical societies, and considers very briefly the extent to which such election is the result of purely professional competence. A few other groups have been included for purposes of comparison, namely, the presidents of the United States, and the presidents of the American Bankers Association, the United States Chamber of Commerce, the International City Managers' Association, and the National Association of Manufacturers.

For a total of 68 groups the names of both their current and former presidents, and the years during which these persons were first elected to the presidency were assembled (Table 1). This information was obtained from society secretaries and from other official sources such as society directories, annual transactions, special journal articles, the *National Encyclopedia of Biography* (*1*), and the like. The number of individuals who have actually held presidencies of professional organizations is more in some instances than the number indicated in Table 1. This discrepancy is the result of the fact that the birth dates of some individuals were not available to me.

The oldest society on the list is the American Statistical Association (founded 1839); the youngest is the American Society of Newspaper Editors (founded 1922). The largest is the National Education Association, with a membership of approximately 500,000; the smallest is the American Gynecological Society, which has only 123 members.

Although this study presents age data for 3394 presidents and former presidents, it is not possible to specify the exact number of different individuals included in the study, for some of them served as presidents of the same organization more than once, and others served as presidents of two or more societies. For example, Simeon Baldwin (1840–1927) held three different presidencies, namely, those of the American Bar Association, 1890–1891 (at age 50); the American Historical Association, 1906 (at age 66); and the American Political Science Association, 1910 (at age 70).

Four former presidents of the United States have been elected presidents of professional organizations. These were Herbert Hoover, president of the American Institute of Mining and Metallurgical Engineers in 1920 (at age 46); Theodore Roosevelt, president of the American Historical Association in 1912 (at age 54); William Howard Taft, president of the American Bar Association in 1913 (at age 56); and Woodrow Wilson, president of the American Political Science Association in 1910 (at age 54) and also president of the American Historical Association in 1925 (at age 67). It is of interest that three of these four men were elected presidents of profes-

sional organizations *after* they had become ex-presidents of the United States.

The youngest of the society presidents was J. Elmer Thomas (1892–1949), who became the first president of the American Association of Petroleum Geologists in 1917 at age 25. The oldest was George Bancroft (1800–1891), who was elected first president of the American Historical Association in 1886, the year that association was founded, at the advanced age of 86.

Table 1 reveals that for 11 organizations the mean age at time of first election to the presidency is in the forties, for 8 of them it falls in the sixties, and for the remaining 49 (72 percent of all groups) it falls in the fifties. The fifties are thus the years during which professional prestige of the kind discussed here is most likely to be attained.

Age-curves were drawn for each of the 68 groups of presidents listed in Table 1. Curves were also drawn for the earlier elected half and for the most recently elected half of each of 45 groups that have had sufficient numbers of presidents to justify partitioning the data in this manner.

A slight tendency for older organizations to elect older presidents is revealed by the following facts: (i) the median of the mean ages of the earlier elected 50 percent of 45 groups is 51.25 years, and the median for the more recently elected 50 percent of the same 45 organizations is 56.81 years, an increase of 5.56 years; (ii) The correlation be-

Table 1. Mean ages at time of first election of presidents of 66 national learned, scientific, and technical societies (listed from oldest to youngest according to the mean age of the presidents).

Name	Date founded	Approx. No. of members	No. of presidents	Mean age of presidents	Distribution (σ)	Elected at age 60 and up (%)
American Bar Association	1878	49,000	77	63.98	8.75	66
American Society of Civil Engineers	1874	34,000	82	63.26	6.89	71
American Ophthalmological Society	1864	225	51	63.09	7.91	76
American Historical Association	1884	6,000	66	63.06	7.48	65
Geological Society of America	1884	2,600	62	62.03	7.30	61
American College of Surgeons	1913	18,000	35	61.61	5.56	57
American Surgical Association	1880	350	68	60.90	7.94	49
American Medical Association	1847	141,000	105	60.02	8.43	39
American Gynecological Society	1876	123	67	59.25	7.35	46
Modern Language Association of America	1884	7,000	61	58.68	9.54	46
American College of Physicians	1915	7,800	27	58.39	6 57	48
American Political Science Association	1904	4,500	47	58.12	5.81	30
American Association for the Advancement of Science	1848	48,000	104	58.03	9.04	43
Association of Military Surgeons of the United States	1891	5,900	40	57.65	6.04	38
National Association of Manufacturers	1895	20,000*	27	57.61	5.82	26
American Institute of Architects	1857	9,300	30	57.50	7.00	37
Seismological Society of America	1906	700	21	57.50	8.70	33
National Sculpture Society	1893	335	20	57.30	6.18	5
American Psychiatric Association	1844	7,100	72	57.13	7.26	26
Entomological Society of America	1906	1,500	46	56.63	8.74	35
American Laryngological, Rhinological and Otological Society	1896	472	46	56.20	8.37	35
American Institute of Mining and Metallurgical Engineers	1871	17,000	72	55.81	9.20	29
American Economic Association	1884	7,400	54	55.50	7.00	26
Association of American Geographers	1904	1,800	49	55.38	6.36	22
American Public Health Association	1872	13,000	72	55.37	7.43	32
American Sociological Society	1905	4,500	43	55.24	6.50	23
American Chemical Society	1876	66,000	63	55.13	8.63	29
American Society of Newspaper Editors	1922	500	22	54.77	7.94	23
American Newspaper Publishers Association	1887	787†	27	54.72	10.66	30
Chamber of Commerce of the United States	1912	21,000	24	54.50	7.23	30
American Society of Mechanical Engineers	1880	38,000	66	54.45	7.46	47
American Anthropological Association	1902	2,400	37	54.42	7.40	24
American Physical Society	1899	10,500	39	54.35	7.77	26
American Institute of Chemical Engineers	1908	13,000	34	54.18	6.22	37
American Bankers Association	1875	93,000	66	54.14	7.52	29
Botanical Society of America	1894	18,000	54	54.14	10.54	26
American Neurological Association	1875	342	64	54.12	11.13	30
American Association of Anatomists	1888	1,000	31	54.11	6.58	23
American Philological Association	1869	1,050	82	53.60	9.21	26
American Association of School Administrators	1865	8,700	70	53.19	7.47	29
American Dental Association	1860	76,000	86	53.01	8.01	22
National Education Association	1870	500,000	68	52.94	8.48	21
American Statistical Association	1839	4.500	46	52.67	7.33	24
American Society of Naturalists	1883	655	66	52.58	8.42	20
American Library Association	1876	20,000	64	52.52	7.52	19

Name	Date founded	Approx. No. of members	No. of presidents	Mean age of presidents	Distribution (σ)	Elected at age 60 and up %
American Society of Zoologists	1890	1,285	57	52.07	9.35	18
American Pharmaceutical Association	1852	24,000	94	51.76	9.97	23
American Dialect Society	1889	600	21	51.21	9.59	19
American Orthopedic Association	1887	251	57	50.97	7.37	25
American Society of Agronomy	1908	2,300	46	50.84	8.54	18
American Microscopical Society	1878	530	63	50.44	10.14	19
American Institute of Electrical Engineers	1884	44,000	72	50.35	9.71	19
Society of American Foresters	1900	9,500	25	50.30	9.12	24
American Association on Mental Deficiency	1876	1,765	29	50.26	11.11	21
American Mathematical Society	1889	4,400	31	50.24	6.46	3
Society of American Bacteriologists	1900	4,400	53	49.76	8.66	11
Society of Automotive Engineers	1905	23,000	48	48.75	8.14	10
American Dairy Science Association	1906	1,500	36	48.24	7.72	3
American Society of Economic Entomologists	1889	3,000	62	48.23	9.02	10
American Association of Petroleum Geologists	1917	10,000	37	48.04	8.91	8
Astronomical Society of the Pacific	1889	700	38	47.33	9.21	13
American Educational Research Association	1915	900	36	47.33	7.41	8
International City Managers Association	1914	1,700	34	46.82	8.54	9
American Society of Agricultural Engineers	1908	3,700	33	46.68	8.42	9
American Osteopathic Association	1896	8,300	46	46.50	6.97	4
American Psychological Association	1892	10,000	60	46.05	6.11	0‡
Presidents of the United States			30	55.90	5.73	23
Women presidents of the societies listed			81	52.01	8.81	16

* More than 20,000 organizations. † Number of daily newspapers.
‡ Data are given here for *first elections only* of 60 past presidents of the American Psychological Association. In addition to these 60, William James was elected to a second term at age 62 and G. Stanley Hall was elected to a second term at age 68. Prior to the present time no one has been elected president of the APA (for the first time) at as late an age as 60.

tween the ages of 66 societies (*2*) and the mean ages of their former presidents is +0.28; (iii) The correlation between the ages of 66 societies (*2*) and the percentages of their former presidents who first were elected at age 60 or over is +0.26. In other words, there is a slight, but only a slight, tendency for older professional societies to elect older presidents.

Table 2 reveals the number of societies for which the mean ages of the earlier elected and the mean ages of the most recently elected fall within a given decade of life. This table shows that, as compared with the earlier elected presidents, the mean ages of the more recently elected tend very definitely to fall in an older decade of life.

For 66 groups the correlation between the present number of members and the mean ages of their past presidents was computed by two methods: (i) by ranking the organizations according to the present number of members; (ii) by ranking the organizations according to the *logarithms* of the present number of members. By the first method, the coefficient of correlation was +0.08; by the second method, +0.07. Neither of these correlations is significant.

When the number of present members was correlated with the ages of only those presidents holding office during the year 1950, the correlations were +0.07 and −0.05, respectively. It seems a safe conclusion that there is little or no relationship between the number of members and the ages of a society's presidents.

An effort was made to construct separate age-curves for several women's organizations, including the American Home Economics Association, the National Association of Women Artists, the American Association of University Women, and the National Society of Daughters of the American Revolution. Although the secretaries of these women's societies were most cooperative in providing the names of their former presidents, the attempt to find their birth dates was not particularly successful. A disconcerting number of women who have achieved contemporary eminence and whose names appear in biographical directories have failed to give their birth dates.

By selecting from 66 organizations the names of

Table 2. Number of professional societies for which the mean ages of the earlier elected 50 percent and the mean ages of the most recently elected 50 percent fall within a given decade of life.

Decade	Earlier elected 50%	Most recently elected 50%
Ages 40 to 49	13	1
Ages 50 to 59	27	34
Ages 60 to 69	5	10
Totals	45	45

all present and former women presidents with known birth dates, data for 81 women presidents were obtained. The mean age was 52.61 years. In view of Norman's finding that there is an increasing percentage of age concealment among women psychologists as women grow older (*3*) it seems likely that the foregoing mean is not based on a wholly random sample of former women presidents, and that the actual mean age is probably somewhat more than 52.61 years. In any case, women, like men, tend most often to be elected presidents of their professional societies during the fifties.

Figure 1 presents age data for the 3394 presidents of the 68 groups listed in Table 1 according to the *average* number of presidencies attained per 5-year interval. Adequate allowance is thus made for the larger number of young persons as compared with older ones.

For example, it was found that for the 5-year interval from ages 50 to 54, inclusive, a total of 679 presidencies were attained. This was slightly more than 0.044 of a presidency per individual. The men and women who remained alive at ages 80 to 84 attained only 6 presidencies, which was slightly more than 0.00231 of a presidency per living individual. In Fig. 1 the curve is so drawn as to be only 0.00231/0.044 as high at ages 80 to 84 as at 50 to 54, in order to show graphically by age group the *average* number of presidencies attained per living individual. The peak of the statistical distribution was arbitrarily assigned a value of 100 percent in the construction of Fig. 1.

It will be noted that Fig. 1 exhibits almost a plateau from about age 52 to 62. This is in part the result of the fact that there were included presidents of both societies whose members are mostly research workers and also organizations that include large percentages of professional practitioners, for example, the American Bar Association, the American Medical Association, and the like.

Figure 2 compares the ages at which outstanding

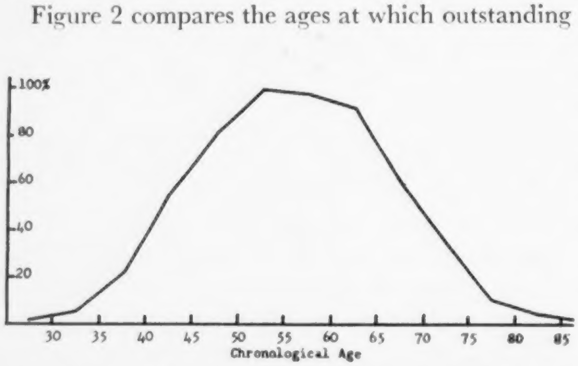


Fig. 1. Age at the time of first election to 3394 presidencies of the 68 organizations listed in Table 1.

creative contributions are made with the ages at which professional recognition by election to a presidency is attained. The solid line in this figure sets forth the ages at which 1359 important creative contributions were made to science, mathematics, and practical invention, reproduced from my book, *Age and Achievement* (*4*). The tabulated data revealed clearly that the most productive period was that from age 31 to age 35. In order to set forth this finding most clearly, the conventional age intervals were altered in constructing this solid line of Fig. 2.

In contrast to the ages at time of notable creative achievement in 13 fields, the broken line of Fig. 2 gives the ages at which 671 persons were first elected presidents of societies which are concerned with research in the same 13 fields. The difference in mean age for the two distributions is 11.59 years, and the peaks of their age-curves differ by approximately 16 years.

The dashed line of Fig. 2 shows the ages at time of first election of 1126 presidents of organizations whose membership includes chiefly professional practitioners rather than research workers. This dashed line reveals graphically that the presidents of practitioner groups are likely to attain their presidential offices at older ages than are the presidents of research groups.

Election to the presidency of a professional organization depends upon a great many things, including, of course, the supposed ability of the one thus elected to fill the position adequately. Therefore there is nothing in this study to reveal the mean ages at which any particular level of contemporary stature is attained in various lines of endeavor. Table 1 merely reveals the mean ages at which various kinds of presidencies have been won. To understand better the causative factors that have produced the age differences shown in this table, it would have been necessary to make a detailed study of each of some 3394 elections. Although I have been unable to do this, the following generalizations have been derived both on the basis of much personal correspondence with society secretaries, and also as a result of some statistical analysis.

1) Although prestige of the kind discussed herein may be attained at any age level from the twenties to the late eighties, the fifties are predominantly the years during which both men and women are most likely to become presidents of their professional organizations.

2) During any calendar year, there is little or no correlation between sizes of membership and the mean ages of the presidents of professional organizations.

3) Although there are many exceptions to the general rule, as was stated earlier, more youthful presidents tend to be elected more often by professional groups that include a large proportion of research workers rather than by those whose memmers are chiefly practitioners.

4) Relatively youthful presidents tend also to be chosen more often by newly-founded professional groups. One possible reason for this is the fact that any new organization is likely to attract to its ranks a group of young men, and hence is likely to have few elderly members from which to pick its leaders. With the passage of time, many of the founders and some of the earliest joiners tend to gravitate to the presidency. When this occurs, the last of the founders and of the early joiners who are elected presidents will obviously be older at time of their election than those elected during the earliest years of the society's existence.

The foregoing statement is bolstered by the following facts. Collectively, the presidents elected during the most recent 10-year interval, from 1940 to 1949, were only 5.45 years older on the average than the presidents elected from 1870 to 1879. But the presidents of societies that have been in existence for 10 or more decades average 8.39 years older than the presidents of the same societies elected during the first decade of the societies' existence.

5) The mean ages of society presidents are probably influenced also by the method of election. For example, candidates for the presidency of the American Bar Association start their candidacies through friends who try to get a movement started. Then the candidate comes out openly and works hard for votes. It seems probable that this method of election tends to produce older candidates than would be the case if there were no electioneering. That is to say, as compared with older lawyers, young and relatively unknown lawyers are probably more hesitant about announcing openly a willingness to be elected president of the American Bar Association and then working hard for votes.

6) The mean ages of society presidents may be influenced also by the fact that some presidencies are likely to be stepping-stones to better jobs, whereas certain others are likely to be very costly in both time and money. For example, when a man is elected president of the American Bar Association he is expected to devote that entire year of his life to the affairs of the association, and with no financial remuneration. This is true also of the presidents of several other organizations.

In reply to a letter of inquiry, a representative of the American Medical Association made the following comment with reference to the presidency of the AMA:

> Certainly few young men would want the job. During the first year as president-elect, and even more so during the second year as president, the incumbent must spend a great deal of time away from his office and his practice. This obviously means that he must arrange with other physicians to look after his patient-load. It is an honorary job and likely to be expensive in both time and money.

It thus seems clear that the attainment of more than average solvency is one of several prerequisites that must be met successfully by potential candidates for the presidencies of such organizations as the American Bar Association and the American Medical Association. Certainly this prerequisite must tend to increase the mean ages of the presidents of both these and of several other organizations.

7) The mean ages of the presidents of the organizations listed in Table 1 are likely to be influenced also by a society's membership policy. For example, no one is even eligible for membership in the American Ophthalmological Society, third oldest of those listed in Table 1, until he has been in ophthalmology for 10 or more years. Clearly this requirement tends to increase greatly the mean age of potential presidents of the AOS. By way of contrast, an individual may attain full membership in the International City Managers' Association, and eligibility for the presidency of the association, in 2 or 3 years.

Numerous other considerations are probably also

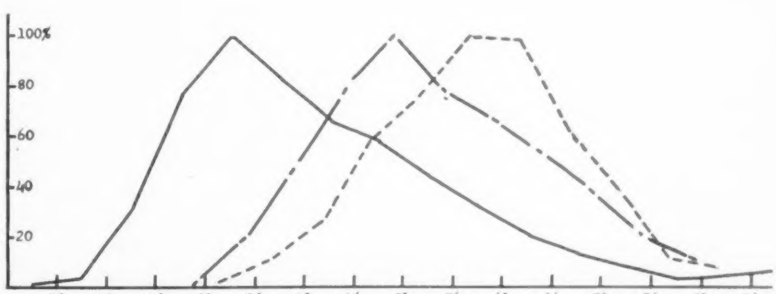


Fig. 2. *Solid line*: age versus production in science, mathematics, and practical invention. *Broken line*: age at time of first election to 671 presidencies of 13 organizations that are concerned with research in the same fields of production. *Dashed line*: age at time of first election to 1276 presidencies of societies whose members are mostly professional practitioners.

effective at one time or another, in one group or another, either singly or collectively. These other factors may conceivably include such things as internal services to the society itself (this seems to be of foremost importance in most groups), individual attainment, conspicuous public achievement, winning personal and social qualities, political skill, wide acquaintanceship and numerous friends, institutional connection, geographical location, whether or not the individual's research specialty is of interest to only a few or to many of his fellowworkers, the number of voting members who are the candidate's former students, and so forth.

Granted that presidents of professional societies are a very able and fine group of men, it nevertheless seems clear that sheer professional merit, in the narrow sense of that term, is not the sole factor that determines whether or not an individual is destined to become the president of his professional group.

References and Notes

1. *National Encyclopedia of Biography*. Index and Conspectus (James T. White, New York, 1935).
2. The last two groups listed in Table 1 have been omitted in the computation of these correlations for obvious reasons.
3. R. D. Norman, *J. Social Psychol.* **30**, 127-135 (1948).
4. H. C. Lehman, *Age and Achievement*. (Princeton Univ. Press, Princeton, N. J. 1953) p. 255.

[In his Friday evening lectures at the Royal Institution, Sir James Dewar] never failed to grip his audience, not by his eloquence nor by the clearness of his exposition—actually he was difficult to follow—but by the extraordinary display he made of experimental illustrations which fascinated by their elegance and originality. Faraday took pains, but he handled simpler themes. Dewar took more pains. The stock illustrations made no appeal to him, but he developed lecture-demonstration to a fine art. In the course of 60 years I have listened to all the great lecturers on Friday evenings—others may have told their story more clearly, more convincingly; but no one has ever approached him in the calculated perfection of his illustrations. He regarded the lecture as an artistic performance, to be staged with absolute forethought and utmost care, provided with original scenery and all necessary appointments, without count of cost. He had the same ambition in the Royal Institution lectures that his friend Irving, the great actor, had on the Lyceum stage. The accounts on record give but the faintest idea of the performances we witnessed.—H. E. Armstrong, *J. Chem. Soc.* (England), 1928, p. 1070.

Crops, Weeds, and Revolution

JACK R. HARLAN

The author is a senior geneticist with the Forage and Range Section of the Agricultural Research Service, USDA, and, since 1951, has been on the faculty of the agronomy department of Oklahoma A. and M. College at Stillwater. A previous article by Professor Harlan appeared in the Feburary 1951 Scientific Monthly.

THE basic outlines of the industrial revolution are familiar to nearly everyone. We are in general aware of the manner in which new sources of energy have been harnessed and put to work for the production of material things. This source of energy, based first on coal and later supplemented by petroleum and hydroelectric power, has profoundly affected man's way of life in the few centuries since the technologic knowledge became available for its use. We are generally familiar with the urbanization, the loss of rural population, the slums and tenements, the smog, the occupational diseases, and the general rise in material wealth and living standards that the revolution has brought wherever it has touched in its sweep around the world. The blessings of the industrial revolution are not unmixed since it has brought economic, social, and political upheavals of unprecedented intensity. The vast new industrial machines are able to support nations in armed conflict as never before, and the instability of revolution has shattered not only the peace of nations but the peace of mind and soul as well.

We are living today in an age of revolution. These are exciting times of great change in which old orders and systems are being destroyed and new systems built. Although these facts are familiar to us because we live with them, it is less generally understood that a revolution of similar importance and intensity took place some thousands of years ago. This can be spoken of as the agricultural revolution and was in no way less important in its effect on man's way of life and in no way less essential to the development of civilization. Of the two revolutions, in fact, the agricultural revolution was the more basic and fundamental and was a prerequisite for the industrial revolution.

The agricultural revolution consisted of that period of time when man passed from a *food-gathering* society to a *food-growing* society (*1*). It involved the domestication of crop plants. As was the case in the industrial revolution, a new and stable source of energy was required. This was provided by crops that would produce enough at one harvest to last until the next—crops that would produce surpluses beyond the essential needs of an individual grower and his family. The domestication of our primary food crops took place, however, in prehistoric times. There is no documentation, and our information concerning the agricultural revolution and the domestication of plants that preceded it must come by indirect means. The piecing together of the various lines of evidence has become one of the most fascinating detective stories of modern science.

Since cultivated plants are the source of energy for agricultural people, let us begin with a consideration of the crop plants themselves. Our primary crop plants are of very ancient origin. It has been said, and in a sense quite correctly, that "not a single staple crop has been added to the human diet since the Stone Age." All of the great basic food plants of mankind were domesticated and improved by Stone Age men. Such crops as wheat, barley, rice, sorghum, corn, potato, sugar cane, beans, millet, manioc, sweetpotato, banana, plantain, date, and coconut all date back to prehistoric times. All of them have provided the stable source of energy upon which civilizations depend. These were the fuel of the agricultural revolution as it swept around the earth, just as coal, oil, and hydroelectric power have provided the energy for the industrial revolution.

The origin of some of our cultivated plants is rather easily determined, since they are but slightly different from the wild forms of today. The origin of others, however, is quite obscure. Wild forms of corn, beans, tobacco, the bread wheats, and bananas are quite unknown. It was thought at one time that these crops were so ancient that the wild progenitors have since become extinct. Modern cytogenetic evidence, however, indicates another alternative.

The civilization of Western man has been based on the culture of wheat more than any other crop. It has traditionally been our staff of life and is the floor of our standard of living today. Furthermore, more evidence is at hand concerning its do-

mestication and the consequences of its use than in the case of other basic food plants. It serves as an excellent example, and evidence brought to bear on the problem of its origin by studies in several fields is summarized here.

Cytogenetics. Using *wheat* in its broad sense, there are three primary types depending on chromosome number. The diploids have 7 pairs at germ-cell division or one genome, which is conventionally represented by the letters *AA*. The tetraploids have 14 pairs at germ-cell division and have two genomes, mostly represented as *AABB*. The hexaploids have 21 pairs at germ-cell division representing three genomes, *AABBCC*. Thus, when a diploid and a tetraploid are crossed, the F_1 has the constitution *AAB* and should have 7 pairs and 7 unpaired chromosomes at meiosis. If a tetraploid is crossed with a hexaploid, the F_1 has the constitution *AABBC* and should have 14 pairs and 7 unpaired chromosomes at meiosis. This is approximately the case (*2*). There are complications, however, since still other genomes are known, such as the tetraploid *Triticum armeniacum* (Jakub.) Makush, which is given the designation *AAGG*.

Crosses with closely related genera indicate that the *B* genome is found in several species of *Agropyron*—the wheat grasses, and the *C* genome is present in certain species of *Aegilops*—the goat grasses. The general picture is briefly as follows.

Diploid: Wild forms are known in the Near East consisting of *Triticum aegilopoides* (Link.) Bal. and *T. thaoudar* Rent. and having the genomic constitution *AA*. These have given rise to the cultivated einkorn *T. monococcum* L.

Tetraploid: Wild forms are known in the Near East including *T. dicoccoides* Körn with the genomic constitution *AABB* and *T. armeniacum* (Jakub.) Makush., *AAGG*. The former has given rise directly to the cultivated emmer *T. dicoccum* Schrank. and less directly perhaps to most of the cultivated tetraploids, including the macaroni wheats. The other wild form may be the progenitor of *T. timopheevi* Zhuk., a rather rare cultivated form with very high disease resistance.

Hexaploid: No wild forms are known. The bread wheats were probably derived by genome building and subsequent hybridization with certain tetraploid types. Most probable origin is *T. dicoccum AABB* × *Aegilops squarrosa CC* followed by chromosome doubling to make a hexaploid with the constitution *AABBCC*. Such a form has been produced artificially and is a nearly exact duplication of *T. spelta*, an ancient wheat still grown on a small scale in mountainous areas of Europe. Spelt is not free threshing, but this character can be readily introduced by crossing with tetraploid forms.

This process of genome building almost certainly did not happen only once. It has, no doubt, occurred on several occasions involving various forms of *Triticum, Agropyron*, and *Aegilops*; nor can *Secale* and *Haynaldia* be ruled out of the picture. This much at least we can say concerning the cytogenetic evidence: The *AA* types occurred in the wild and were domesticated directly. The *AABB* forms were produced by alloploidy under natural conditions and were also domesticatetl directly. The *AABBCC* type was produced later by alloploidy at a time when the emmers were already extensively grown. The bread wheats came last and appeared under domestication (*3*).

The field of cytogenetics has been most useful in providing information concerning the origin of a number of other crops. Tobacco, like the bread wheats, is unknown in the wild, not because it is such an ancient crop that the wild progenitor has become extinct, but because it too is an alloploid arising under conditions of domestication. The banana produces no seeds, because it is a sterile triploid hybrid between two species of plantain. The case of corn remains obscure. It is not exactly an alloploid, but evidence suggests that at least two genera were involved in its origin. The cytogenetic evidence is also important in the case of rice, cotton, oats, and a number of other crops. Cytogenetics, then, provides us with evidence concerning the sequence of events. The next question is *when* did these events take place.

Crop Geography. Without entering into a discussion of the Vavilovian theories of crop geography, some of which are not on firmly established ground, it can be shown that the present distribution of the *dramatis personae* is very enlightening. The hexaploid bread wheats are, of course, grown around the world today. We know them to have been of Old World origin, because the crop was unknown to the American Indians. The crop too was little grown in Africa, except along the Mediterranean coasts, until it was introduced by Europeans. By elimination it is a Eurasian crop, but where in the vastest of all continents the bread wheats originated is difficult to establish by present cultural dispersion patterns. If, however, *Aegilops squarrosa* was indeed the primary source of the *C* genome, our focus is sharpened considerably, since this is a weed of Mediterranean climates.

The present distribution of the macaroni wheats also covers a wide region of Eurasia but is not nearly so extensive as that of the bread wheats (*4*). When we direct our attention to the more primi-

tive emmers, however, we are drawn once again to the eastern end of the Mediterranean. Ethiopia and Asia Minor are the two centers of extensive use of this crop. Finally, when the wild forms are considered, the most likely region of domestication is narrowed still more. *Triticum dicoccoides, T. aegilopoides*, and the other wild forms occur naturally today in Asia Minor, Greece, Syria, Palestine, and Iraq. The Ethiopian center is ruled out, and we have narrowed the most likely region to a relatively small area between the horns of Breasted's "Fertile Crescent."

It can be argued, of course, that present distribution patterns are different from those of several thousand years ago. Fortunately, there is a considerable body of corroboratory evidence for the conclusion just drawn (*5*). Having established within moderate limits *what* happened and *where* it happened, the next question is *how* it happened.

Crop Domestication. Students of crop domestication are likely to place great stress on the role of weeds in the origin of crop plants. Indeed, it is obvious that weeds and crops are adapted to the same conditions. If weeds were not well adapted to the conditions of the cultivated field, they would be very easy to control. On the contrary, they are so well suited to cultivation that they are sometimes easier to raise than the crop. In fact, some weeds are quite rare in nature—being confined to the disturbed areas of what are called pioneer sites, such as along stream banks, floodplains, cliffs, steep talus slopes, at the edge of glaciers, the seashore, or sand dunes. The yearly disturbance of the soil by tillage is to their liking, and plants that would otherwise be quite rare or unimportant have become some of our most serious and pernicious weed pests.

Now, if a weed—that is, a plant adapted to the environment of cultivation—had any merit in its own right, such as edible seeds, fruits, stems, leaves, tubers, or roots, or if it produced oil, fiber, or some pharmaceutical product, it would very quickly be introduced into cultivation. Crops that arose as weeds in a more ancient crop were called by Vavilov "secondary crops." Examples are rye, a common weed in wheat, and oats, a weed of emmer. Vetches, lentils, field peas, chicory, and rape are other examples.

Vavilov gives as one illustration the case of rye in Afghanistan. Here at the lower elevations wheat is the most common crop. As one passes to higher elevations, the fields become infested with weed-rye. At middle elevations, the pest becomes quite serious. The peasants go so far as to try to sweep the seed out of the fields with brooms after harvest. At still higher elevations, the farmers give up and

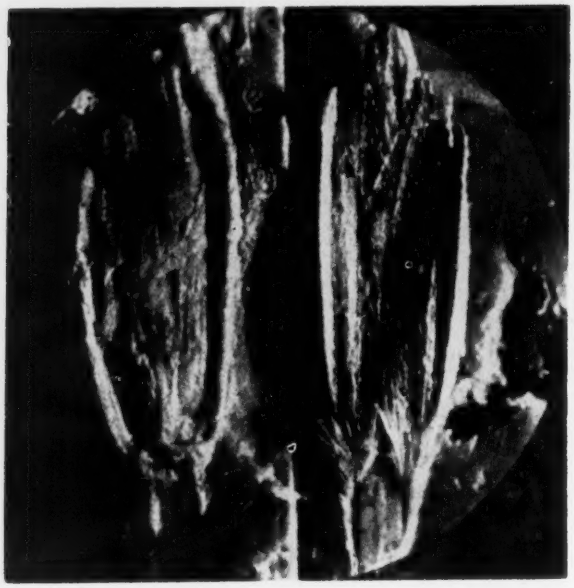
Ventral side of Jarmo emmer spikelet (cast) compared with neolithic Egyptian emmer (right). Note heavy glumes of Jarmo material. [Courtesy H. Helbaek, National Museum, Copenhagen]

grow rye. All stages of domestication are clearly visible today.

But some of our primary crops also have somewhat weedy habits and very likely were first brought to the attention of the earliest agriculturalists by their habit of growing in disturbed sites around the dwellings, the camps, the village refuse heaps, and the bedding grounds of the community herds. Man has seldom appreciated his debt to the weedy plants of the world. These are the plants from which man first selected his primary crops. Weeds have added to our agricultural heritage in producing secondary crops and in contributing germ plasm to primary crops. *Aegilops squarrosa* is a very humble sort of a weed of no evident value whatever; yet, as we have seen, it has made a billion-dollar crop out of a million-dollar one by introducing the *C* genome into wheat.

This line of thought has been pursued in much more detail by other students of plant domestication (*6*). Perhaps it is enough to suggest here that we have a fairly good picture of *how* wheat became domesticated and, within limits, *where* it was first cultivated. Our next question is *when* did this take place. For this answer we must invade still another discipline.

Archeology. Recent excavations conducted by the Oriental Institute of the University of Chicago under the general direction of Robert Braidwood have provided some very significant information. The earliest farming village site so far studied in



Ventral side of Jarmo emmer spikelet (cast) compared with recent *T. dicoccoides*. The Jarmo material evidently resembles the wild form more closely than the cultivated emmer of the Egyptian neolithic. [Courtesy H. Helbaek, National Museum, Copenhagen]

detail is Jarmo located in the Kurdish foothills between Mosul and Sulemaniya in Iraq. Topologically the site is neolithic from top to bottom. The lower layers, which are of course the oldest, contain no portable beakers, vessels, or ceramics. Midway through, the mound stone beakers appear and later primitive pottery. Among the stone tools are large numbers of small, worked flakes of obsidian and flint called microliths. Most of these had once been mounted in a haft of wood or bone. They were, in fact, sickle teeth used to harvest the cereal crops of these early farmers (*7*).

The plant materials of interest here were painstakingly examined and positively identified by Hans Helbaek of the National Museum of Copenhagen, Denmark. Three cereals were present: (i) two-rowed barley that was intermediate between the wild *Hordeum spontaneum* of that region and the two-rowed barley of today, (ii) an einkorn that is intermediate between the wild *T. aegilopoides* and the cultivated *T. monococcum;* and, (iii) an emmer also intermediate between the wild *T. dicoccoides* and the tame *T. dicoccum.* Both the emmer and the einkorn have heavier and larger glumes than the modern cultivated forms or even than those grown in the Egyptian neolithic. The barley has pedicellate lateral florets, as the wild forms do, while modern two-rowed barley has sessile lateral florets for the most part (*8*).

Jarmo, then, does not represent the very first attempt to grow wild cereal grasses, but it does transect a period of time when the wild cereals were being domesticated. The date of Jarmo is therefore of much interest to us. There were not sufficient quantities of grains for radiocarbon determinations, but two samples of charcoal were checked against one sample of snail shell, the gastropods apparently being one of the favorite foods of these people. The three dates checked to within 100 years of each other, which at this distance in time represents very close agreement. The average date was 4716 ± 300 B.C. (*9*).

It would be unwise to draw too many conclusions from a single excavation. Many more Jarmos are needed before the picture can be rounded out, but there is considerable supporting evidence to indicate that cereals were being grown in the early 5th millenium B.C., and that these cereals were more nearly like the wild forms than the modern cultivated types.

We may now inquire into the consequences of these early attempts at plant domestication. Actually nothing much happened for well over 1000 years. The culture of plants spread slowly. Emmer and barley are found in the Fayum A deposits of lower Egypt some 600 years after Jarmo. These cereals had reached Sialk in central Persia 1000 years after Jarmo and probably the Indus valley somewhat later. There is no evidence that the introduction of crop plants into neolithic economy had any great effect on man's way of life. The appearance of crop plants no more precipitated an agricultural revolution than the knowledge of coal produced an industrial revolution. Coal had been mined during the Roman occupation of England and was used by the Chinese from early times. It required the inventions of the 18th century and later to precipitate the industrial revolution. In the same way it was the mid-4th millenium B.C. before the technologic knowledge was available to exploit crop plants. The availability of materials and of a source of energy is of no great value unless man learns how to exploit them. Thus, from the time of Jarmo the agricultural revolution had simmered along, building up steam for 12 centuries or more. When it finally came, it burst upon the scene with explosive force, having the character of a true revolution. (*1*).

What happened? First in Mesopotamia and a little later in Egypt there was a dramatic increase in the urban population. City folk are not food producers. They are consumers. No large cities are possible without a stable surplus of food from the producing areas to support the urban dwellers. The archeological record indicates that cities virtually mushroomed on the Mesopotamian plain.

With the first cities came the first large temples.

indicating an advanced religion and a theocratic class. The first writing so far found by archeologists was a form of record keeping in the temples. One might surmise that the priests of that day were more interested in recording tithes than the disposition of men's souls, but at least the foundation of literature and recorded history was laid by the ingenuity of the temple priests of Mesopotamia. With the sudden rise of cities came great advances in metallurgy and home and guild industry; with writing came literature, and creative art was of higher caliber. The organization of city governments resulted in national politics, and nations and empires made their appearance. And so the crisis affected every phase of life (*10*).

The general outlines of the agricultural revolution in the Near East can be pieced together with reasonable accuracy, because we have inherited the crops and the civilization resulting from it. The revolution appeared in different areas at different times based upon other crops and resulting in other civilizations. The evidence is less clear in other parts of the world, but all the information we have indicates that a similar pattern was followed in the New World when corn was developed as a domesticated crop. The sudden appearance of rich urban civilizations in Central and South America indicate the same sort of motive power, the same source of energy as that which brought about the urban civilizations of the Near East. Less is known about our other crops and still less of the prehistory of the cultures based upon them; yet what we have learned about the domestication of the cereal grains of the Near East can be applied in principle to other situations.

Students of history and prehistory are sometimes appalled by the time required for even modest progress. We who live in an era of revolution have seen material progress proceed at a faster rate than ever before. The rate of change is still accelerating, and we who have been privileged to work in the fields of science have each had our small part to play in the dynamics of our times. These are exciting times, and we of all people should be able to look back over the centuries and view with some sympathy and understanding the exciting times of great progress that closed the Neolithic period. Our kinship to our forebears of the late Stone Age is greater than most of us realize. Our heritage includes the crops they produced, the ideas they conceived, and the civilizations they built. Our revolution is no more remarkable than theirs, for Stone Age man's conquest of plants was a dramatic and fundamental episode in the long saga of human development.

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I do not know what I may appear to the world but to myself I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst a great ocean of truth lay all undiscovered before me.—Isaac Newton.

Glimpses of the Human Side of Sir Isaac Newton

HENRY P. MACOMBER

After graduating from Harvard College, the author spent 13 years with the Houghton Mifflin Co., 16 years with the Boston Society of Arts and Crafts, and 3 years with the Cranbrook Foundation in Detroit. Since 1946 he has been curator of the Babson Newton Collection at the Babson Institute Library and associate compiler of the catalog and supplement of the Babson Newton Collection.

FROM my observation, it seems that the average person today has only a vague idea of Sir Isaac Newton as the man who discovered the law of gravitation by observing the fall of an apple. There is a feeling that he was a monument of ascetic austerity—a notion that I hope to contradict with these less familiar glimpses of the human side of Newton.

Emerson said that a great man is one who administers a shock to the world, and he named Newton as an example. Lagrange called Newton "the greatest genius who ever lived," and Conduitt, his nephew-in-law, described him as "a national man." In his recent life of Newton (*1*), Andrade remarks:

> From time to time, in the history of mankind there arises a man whose work, whose viewpoint changes the current of human thought, so that all that comes after him bears evidence of his spirit. . . . Such a great pioneer, such a leader was Newton . . . one of the strangest and most baffling figures in the history of human thought.

During the last years of his life, in his positions as president of the Royal Society and Master of the Mint, he was, to a degree unprecedented for a man of science, the idol of the British people. But the general opinion of him has been that he was a very serious, cool, dignified and unapproachable man, almost puritanical.

Caution was a distinguishing part of his character. There were no humorous books in his library. He sharply rebuked Halley for joking about what he considered a serious subject. His niece, Catherine Barton Conduitt, told how he liked to discuss chemistry with his friend Vigani, at Trinity College, but when Vigani tried to tell him a risqué story, he broke off all acquaintance with him (*2*, vol. II, p. 93). His secretary, Humphrey Newton, who knew him only during a few years when he was working hardest, said he saw Newton laugh only once (*3*, p. 57; *4*, p. 252),

> . . . upon occasion of asking a friend, to whom he had lent Euclid to read, what progress he had made in that author and how he liked him. The friend answered by desiring to know what use and benefit in life that study would be to him. Upon which Sir Isaac was very merry.

On the other hand, Stukeley, who knew Newton in his later years, goes on to say:

> According to my own observation, tho' Sir Isaac was of a very serious and compos'd frame of mind, yet I have often seen him laugh, and that upon moderate occasions. He had in his disposition a natural pleasantness of temper and much good nature, very distant from moroseness, attended neither with gayety nor levity. He used a good many sayings bordering on joke and wit. In company he behaved very agreeably; courteous, affable, he was easily made to smile, if not to laugh.

There is no doubt that Newton was easily irritated and had a morbid sensitiveness and an abnormal dread of controversy. Whiston, who quarreled with him, said that "he was of the most fearful, cautious and suspicious temper that I ever knew." And Flamsteed, who also quarreled with him, said he was "insidious, ambitious and excessively covetous of praise and impatient of contradiction." His friend, John Locke, described him as

> . . . a nice [meaning difficult and overprecise] man to deal with, and a little too apt to raise in himself suspicions where there is no ground.

Newton certainly had a very human side. He was generous in the extreme. While at college, he spent 4 shillings 6 pence "for oranges for my sister," as he enters it in his notebook. Later he gave 50 pounds toward the building of a new library at Trinity College, which was a large donation for a

professor. He provided a fund, from the income of which Bibles were given each year to poor people, administered by the father of his "chamberfellow," John Wickins. When Newton left Trinity, he gave Wickins all the furniture in his rooms (*2*, vol. II, p. 86). For some years, Newton supported the family of his deceased nephew-in-law Pilkington (*4*, p. 250). He made many gifts to his niece, Mrs. Conduitt and her husband, and gave their daughter 4000 pounds shortly before he died. He gave Samuel Clarke 500 pounds for translating the *Opticks* and paid Pemberton 200 pounds for editing the third edition of the *Principia*. The Reverend James Pound furnished him with astronomical information and received more than 100 pounds as a free gift (*5*). In 1720 the Royal Society lost 600 pounds by subscribing to the South Sea stock, and Newton offered to reimburse the society, but his generous offer was refused (*3*, p. 13). More says (*4*, p. 135):

> Newton could not bear the sport of hunting and objected to one of his nephews because he killed birds.

Conduitt states that Newton was much interested in making and improving ear trumpets and went to some pains to describe them to a deaf man whom he met at the Royal Society.

A notebook that Newton had during his last days in school and his first at Trinity College (1659–61), which first reappeared at the Lymington sale in 1936, was purchased by the Pilgrim Trust in 1950 and presented to Trinity College Library. As might be expected of a college freshman, he records in this notebook how much he "lost at cards" and spent "at ye Tavern," but also that he purchased "ye Hystory of ye Royall Society," "Philosophicall Intelligences," "A chess board and Chesse Men," and so forth. Among "idle and vain expenses" he includes "Bottle beere, China ale (tea), Marmolet (marmalade), Custords, Cherries and Tarte." Seward reports that Newton used to play "backgammon" with Flamsteed, the astronomer (*4*, p. 542).

As evidence of Newton's shyness, he himself said (*6*):

> I see not what there is desirable in public esteem, were I able to acquire and maintain it; it would perhaps increase my acquaintance, the thing which I chiefly study to decline.

At the age of 30, Newton's hair was already turning gray, but he never became bald, never used eyeglasses, and lost only one tooth. "His breakfast was orange peel, boiled in water, which he drank as tea, sweetened with sugar, and with bread and

Chimney corner of the original kitchen at Woolsthorpe Manor House, the birthplace of Newton in 1642, as it looks today. [*Courtesy the Babson Newton collection.*]

butter." His cure for a cold was to stay in bed for 3 days to rest and perspire (*7*). When Newton was offered snuff or tobacco, he declined, saying "that he would make no necessities to himself (*2*, vol. II, p. 410)."

His secretary said of Newton (*4*, pp. 247–50):

> I never knew him to take any recreation or pastime, either in riding out to take the air, walking, bowling, or any other exercise whatever, thinking all hours lost that were not spent in his studies.

However,

> . . . he was very curious in his garden, which was never out of order, in which he would at some seldom time take a short walk or two, not enduring to see a weed in it. . . . When he has sometimes taken a turn or two, he has made a sudden stand, turn'd himself about, run up the stairs like another Archimedes, and with a *eureka*, fall to write on his desk, standing without giving himself the leisure to draw a chair to sit down on. . . . In his chamber he walked so very much you might have thought him to be educated at Athens among the Aristotelian sect [the Peripatetics]. . . . In winter time he was a lover of apples and sometimes at night would eat a small roasted quince.

In two letters to Oldenburg in September and October 1676, Newton is seen in the role of a country gentleman inquiring about the best apple trees for making cider. He says that the famous Red Streaks, which make fine cider elsewhere, make harsh cider in Lincolnshire. He asks with what fruit they should be mixed, in what proportion, and what degree of ripeness; should they be

pressed as soon as gathered, or should they be pared. "Our gardeners," he says, "find more profit in cherry trees (*2*, vol. I, pp. 129–30; *4*, p. 182)." The famous apple tree at Woolsthorpe was the variety known in Lincolnshire as Flower of Kent. The apple is shaped like a pear, red streaked with yellow and green and rather flavorless. (Babson Institute has a direct descendant of the original tree.)

Newton had considerable ability as a mechanic. As a boy he made kites, paper lanterns, sundials, windmills, wooden clocks, and water clocks. Later he ground and polished lenses, prisms, and burning glasses and made two reflecting telescopes, which he invented in practically the same form as the great 200-inch Palomar telescope today. De Villamil thought he might have made the "Newton Chair," now in the Royal Society Library, the only piece of his furniture that has come down to us. He sat for portraits in this chair; it was later used by Sir Joshua Reynolds and at the dedication of Newton's statue at Grantham in 1856. Newton's secretary said that he made and altered his brick furnace himself without troubling a bricklayer (*4*, p. 249). He made a fine improvement in optics by observing some boys blow up soap bubbles (*8*).

Newton was not interested in poetry, although he may have written the 10 lines of indifferent verse under the portrait of Charles I that he owned. Lord Radnor said that a friend once asked him: "Sir Isaac, what is your opinion of poetry?" His answer was (*9*, p. 10): "I'll tell you that of Barrow; he said that poetry was a kind of ingenuous nonsense."

The artistic side of music does not seem to have interested Newton, but Stukeley heard him say that operas were very fine entertainment, but there was too much of a good thing; it was like a surfeit at dinner. Said Newton (*3*, p. 14; *4*, p. 475):

> I went to the last opera. The first act gave me the greatest pleasure. The second quite tired me. At the third I ran away.

Newton found in musical harmony the principle of law and order of the cosmos. According to More (*4*, p. 476):

> He thought Pythagoras' music of the spheres was intended to typify gravity, and, as he makes the sounds and notes depend on the size of the strings, so gravity depends on the density of matter.

He believed that multiples of harmonic ratios, based on Euclid, furnished those ratios that afford pleasure to the eye in architectural designs and to the ear in music.

Newton was not especially interested in art and despised collectors. He said of Lord Pembroke (*9*, p. 16):

> Let him have but a stone doll and he is satisfied. I can't imagine the utility of such studies; all their pursuits are below nature.

He had his portrait painted by Charles Jervas and presented it to the Royal Society, "for which he had their thanks." The inventory of his possessions listed 210 prints, 19 lithographs, 4 pieces of tapestry, a figure cut in ivory of Sir Isaac in a glass frame, 13 India prints, 6 gold rings and 1 onyx stone, cut, 39 silver medals, and 1896 books. Some of these books are now scattered, but 860 of them were purchased by the Pilgrim Trust in 1943 and permanently deposited in Trinity College Library. King's College Library has some of them, and 13 are in the Babson collection. De Villamil believed that Mead, who was Newton's physician and a famous collector, commissioned David le Marchand to make for him, from life, the fine ivory bust of Newton which is now in the British Museum and, at the same time, had him make the small relief portrait listed previously, which he presented to Newton. There are now in existence three relief portraits of Newton in ivory: one in the Babson collection, one in the Royal Society, and one in King's College Library. Whether any one of these is the one that belonged to Newton will probably never be established. The Babson collection also has a gold ring set with sardonyx cut with the head of Newton. It came from the Mont collection and is inscribed: "Presented to Sir John Herschel." It may be that this is the "onyx stone, cut" that belonged to Newton.

Crimson seems to have been Newton's favorite color—or perhaps it was that of Mrs. Conduitt, his niece and housekeeper. The inventory mentions crimson mohair curtains, a crimson mohair bed, and a crimson "sattee." De Villamil ventured to suggest (*9*, p. 15) that

> . . . living in such an atmosphere of crimson may have been one of the reasons why Newton became rather irritable toward the end of his life.

Newton made an ingenious attempt to construct a universal language on a philosophic basis, which, however, he never completed. His main principle was the formation of words from arbitrary roots by the addition of prefixes and suffixes that modified the meaning (*10*).

About 1699, he drew up a plan to rectify the Julian calendar, which he demonstrated to have advantages over the recently adopted Gregorian calendar (*10*, p. 60). Newton made the first satis-

A hitherto unpublished view of Bullingham House, Pitt Street, Kensington, where Newton died in 1727. It was later called Orbell's Buildings and was torn down in 1895. [*Courtesy the librarian, Kensington Reference Library.*]

factory life insurance tables and laid the mathematical foundations on which our textbooks in algebra and geometry are still written. The famous Babsonchart is based on Newton's law of action and reaction.

A curious sidelight on Newton is found in a book, published in 1714, on *The Inn-Play or Cornish-Hugg Wrestler.* The author, Sir Thomas Parkyns, who lived in the town of Bunny, near Grantham, says:

> The Use and Application of the Mathematicks here in Wrestling, I owe to Sir Isaac Newton, Mathematicks Proffessor of Trinity College in Cambridge, who seeing my Inclination that Way, invited me to his public Lectures, for which I thank him.

Newton was something of a mystic, and quotations from Jacob Boehme's works were found among his papers. He seems to have been interested in the Rosicrucians, for in his own library was a book entitled *The Fame and Confession of the Fraternity of R. C., Commonly of the Rosie Cross,* by Eugenius Philálethes (Thomas Vaughan). On the flyleaf is inscribed in Newton's hand: "Is. Newton. Donum Mr. Doyley." Newton may also have been interested in the Society of Druids. It is said that a Druid meeting was held at his London house and Stukeley, who was one of Newton's closest friends during the last 9 years of his life, was the Arch-Druid.

In the recently published *London Journal (11)*, James Boswell quotes Dr. Johnson as saying: "Sir Isaac Newton set out as an infidel, but came to be a very firm believer."

The first copies of Newton's works to come to America were probably the second edition of the *Principia* and the first edition of *Opticks*, which Newton personally presented to the new Yale College Library through Jeremiah Dummer in 1714. It was some time, however, before Yale made much use of them. Harvard had a copy of the *Opticks* in 1723. Isaac Greenwood, the first Hollis professor of mathematics and philosophy, may have brought back a copy of the *Principia* when he returned from England in 1722, but the first copy we are sure of, at Harvard, belonged to John Winthrop IV, who during the 41 years he was Hollis professor until his death in 1779, was the first great disciple of Newton in America. His *Principia* was a third edition and it is now, curiously enough, not at Harvard but in the Brasch collection at Stanford University. John Logan, who was secretary to William Penn,

probably brought the first copy of the 1687 edition of the *Principia* to Philadelphia in 1708. It is now in the Library Company of Philadelphia. In 1680 Thomas Brattle of Boston sent to Newton an excellent series of comet observations, for which Newton expressed his commendation (*12*).

One of the first American appraisals of Newton is found on page 25 in the inaugural oration of Walter Minto at Princeton in 1788. He says:

> Perhaps no man was ever more praised than Sir Isaac Newton; and perhaps no man ever deserved so much to be praised. For, to the most penetrating sagacity, the most exhalting genius, and the most unwearied patience, he joined the highest degree of modesty, temperance and uprightness. He loved science for its own sake, and because it conducted him to the Supreme Cause of All.

In one of Newton's manuscripts entitled "Notanda chymica" he makes one of his very few allusions to America in saying: "Populi Americani in Peru aurum mollificare norunt ut instar cerae digitis tractetur." [The American people in Peru have the knowledge of a method to mollify gold so that it can easily be kneaded by hand].

Newton appears almost in the role of a war correspondent in a letter he wrote from London on 20 October 1711 to a Mr. Greenwood at Rotterdam. The British had sent an expedition against Quebec, consisting of 10 ships of the line, with several smaller vessels and transports carrying upward of 5000 soldiers under Brigadier General Hill. Ignorance of navigation and a violent storm caused a heavy loss in transports and men. Newton's letter reads:

> I beg leave to acquaint you (though I do it with a great deal of concern) that on Satturday last, Octob. 17th, new stile, we had notice that the expedition against Canada under the conduct of Collonel Hill & Admiral Walker had miscarried by meanes of foggy & tempestuous weather when the fleet was going up the river of St. Christophers. Eight transport ships with about 800 men on board were cast away by striking upon rocks & the rest escaped narrowly. We have not yet a distinct account of the men that are lost, but Collonel Barton is recconed one of them. Pray assure my cousin, your daughter, that if this sad news proves true, her friends here will take the best care they can of her concerns in England. But I must leave it to yor own discretion to let her know it by such degrees & in such a manner as may least afflict her. My niece, her sister, would have written to her but for the grief she is in.

Benjamin Franklin came very near to meeting Newton. Franklin had arrived in London on 24 December 1724, just before his 19th birthday. He took work as a compositor at S. Palmer's and continued there during most of 1725. He says in his *Autobiography*, page 85, that a Dr. Lyons

> . . . introduced me to Dr. [Henry] Pemberton, at Batson's Coffee house, who promis'd to give me an opportunity, some time or other, of seeing Sir Isaac Newton, of which I was extremely desirous; but this never happened.

He did, however, meet Sir Hans Sloane, who was secretary and later president of the Royal Society. There is a story in England that Franklin set part of the type for Pemberton's *View of Newton's Philosophy*, printed by Palmer in 1728. Franklin mentions composing Wollaston's *Religion of Nature*, but I can find no evidence that he worked on Pemberton's book while at Palmer's.

Sir Henry Dale, then president of the Royal Society, said at the 300th anniversary meeting on 30 November 1942: "We in Britain regard Isaac Newton as still, beyond all challenge, the greatest of our men of science." On the same occasion, Professor Vavilov, president of the Academy of Sciences of the U.S.S.R., wrote:

> The fundamental principles of Newton's physics . . . have stood the hard test of time marvelously well and have fully retained their vast significance to this day. . . . There is no doubt that Newton's atomistic conceptions raise him to an even higher level in our eyes, and make him an even more attractive and unique figure. It may be said that Newton saw through classical physics, right down into its profoundest depths and right out into its ultimate scope.

And Andrade followed in saying that "Newton was capable of greater sustained mental effort than any man, before or since."

We believe that a vast wealth of ideas still lies hidden in Newton's works, awaiting zealous students to discover and use them. For example, the large body of his letters now being prepared for publication by a committee of the Royal Society, offers great possibilities.

A book by William Digby, published in 1902, is based on Newton's delineation of the tangential pull of the moon—a theory that had remained fallow for 250 years, until an Irishman, Hugh Clements, discovered that its proper application made possible the prediction of earthquakes and volcanic eruptions as accurate as the predictions of the eclipses of the sun, moon, and planets. Thus the tides of the atmosphere, with their resultant storm and calm, rainfall and drouth, are more surely predictable than are the tides of the ocean.

Buffon said "genius is patience," and Newton modestly remarked "if I have done any service this way, it is due to nothing but industry and patient thought." Laplace said of the *Principia*: "This is

the best book that ever was written." When it was published in 1687, the price was about 9 shillings. In November 1950 a copy with no special features sold at auction in New York for the record price of $1500.

It has been said that Newton changed alchemy into chemistry, legend into history, astrology into astronomy and magic into physics.

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It is an erroneous impression, fostered by sensational popular biography, that scientific discovery is often made by inspiration—a sort of *coup de foudre*—from on high. This is rarely the case. Even Archimedes' sudden inspiration in the bathtub; Newton's experience in the apple orchard; Descartes' geometrical discoveries in his bed; Darwin's flash of lucidity on reading a passage in Malthus; and Einstein's brilliant solution of the Michelson puzzle in the patent office in Berne, were not messages out of the blue. They were the final co-ordinations, by minds of genius, of innumerable accumulated facts and impressions which lesser men could grasp only in their uncorrelated isolation, but which—by them—were seen in entirety and integrated into general principles. The scientist takes off from the manifold observations of predecessors, and shows his intelligence, if any, by his ability to discriminate between the important and the negligible, by selecting here and there the significant stepping-stones that will lead across the difficulties to new understanding. The one who places the last stone and steps across to the terra firma of accomplished discovery gets all the credit. Only the initiated know and honor those whose patient integrity and devotion to exact observation have made the last step possible.—HANS ZINSSER, 1878–1940.

Middle-Atlantic Geographic Corridors

RICHMOND E. MYERS

Dr. Myers received his training at Moravian College, the University of Pennsylvania, and Pennsylvania State University. After teaching in secondary schools, he went to Muhlenberg College where he was chairman of the geology department. He then became geologist for the Pennsylvania Water & Power Company and recently he served as chief of the Bureau of Industrial Research, Department of Commerce of the Commonwealth of Pennsylvania. Dr. Myers is now dean of men and professor of geology at Moravian College, Bethlehem, Pennsylvania.

PROBABLY the most important single factor in the development of transportation in a region is physiography. The physical features of an area determine the type of transportation used and, by creating corridors and barriers, make possible or render impassable certain routes, thus establishing the lines over which transportation will move. The significance of physical features is basic in the utilization of any region insofar as its transportation facilities are concerned. For this reason the examination of physiographic factors is important to a complete understanding of the economic development of any region. The Susquehanna Valley offers a splendid example (*1*).

Three major physiographic factors have overshadowed all others in their influence on utilization of the Susquehanna Valley for transportation. The first of these factors has been the Allegheny Front. The second embraced the many water gaps in the transverse ridges of the Valley and Ridge Province. The riffles of the lower river constituted the third factor.

The Allegheny Front, or Allegheny Barrier, appears as a great mountain ridge when it is approached from the southeast, and in Pennsylvania it has been commonly known as the Allegheny Mountain. It has also been called the Endless Mountain (*2*) because of its great extent. In reality it is the southeast-facing escarpment of the Appalachian Plateau and extends in an almost unbroken curve from the Maryland line in Somerset County to within a short distance of the northeastern corner of Pennsylvania. It is a wall of rock 1000 ft high, broken only by a few very narrow gorges that penetrate the plateau for short distances.

The plateau forms a barrier between the interior lowlands of the Great Lakes and the Atlantic seaboard. In New York and Pennsylvania, physiography has supplied only two routes for traveling at easy grade from one side of the plateau to the other. One route is the Mohawk Valley that bypasses the plateau to the north, where, as a result, an easy route is open between the Hudson Valley and the Central Lowlands of the continent. At no point is this route more than 500 ft above sea level.

The other route is the Susquehanna Valley between Tioga Point (Athens, Pennsylvania) and the Wyoming Valley (*3*, p. 339). Here a narrow passageway is open at less than 1000 ft above tide level through the plateau. Unlike the Mohawk passage, the Susquehanna route does not reach from one side of the plateau to the other, but it is the only place where the river opens a true trans-Appalachian route. Its two great tributaries fail in this respect. The Juniata River does not pierce the Allegheny Front, and the West Branch, which does, has no convenient junction valley leading across the divide to a western-flowing river.

At Tioga Point, the Susquehanna passageway offers two easy routes northward. The first, via the Chemung River and Seneca Lake, leads to the Ontario Plains and the Great Lakes. The second, continuing up the Susquehanna, leads, via Otsego Lake or the Schoharie Valley, to the lower Mohawk and middle Hudson country, and then northward, via Lake Champlain, to Canada.

South and east of the Allegheny Front, the parallel transverse ridges of the Valley and Ridge Province rise as formidable barriers to human movement between the Allegheny Plateau and the Atlantic seaboard, except where southeastern-flowing streams have cut their great water gaps through the ridges, thus forming gateways for passage through the mountains. The Susquehanna is not the only river that has carved such water gaps, but because of the unique factors that have influenced the Susquehanna Valley, which were not shared by the other river valleys of Pennsylvania, a more complete

utilization of the Susquehanna corridor was brought about (*4*).

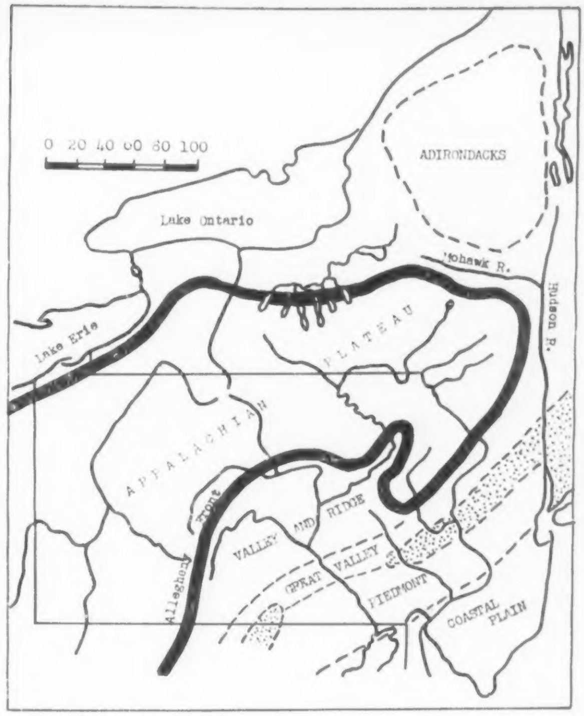
It is not to be assumed that all these factors were physiographic. However, the fact that, in Pennsylvania, only the Susquehanna pierced the Allegheny Front and furnished access with easy grade to lands beyond the Appalachian Plateau, coupled with the fact that the river also flowed south through numerous water gaps in the barrier mountains and across the piedmont to tidewater, is of major significance. This created a corridor from the Chesapeake to the St. Lawrence. Its use, either in whole or in part, became of great importance in the development of transportation in the Susquehanna Valley as well as in the resulting economic development of the areas that the valley served.

There are five of these water gaps, and they lie within the short distance of 19 mi along the river. With an average depth of 700 ft and an average width of 0.7 mi, these passageways form pronounced and spectular openings in the otherwise barrier ridges that lie across the path of the river. It is these water gaps that give the main Susquehanna River its present-day corridor value.

The third physiographic factor that played a major role in the Susquehanna Valley is closely associated with the water gaps. At every point where the river has cut a water gap through a ridge of hard rock, the rock still forms the bed of the river and has barely been eroded below the average level of the river, being covered only at high-water periods and remaining exposed at low-water periods. These ledges of resistant rock have been impediments to navigation ever since man first began to use the river for this purpose (*5*). They are known as riffles and constitute one of the most characteristic features of the river below Sunbury. They occur not only where the hard ridges of the Valley and Ridge Province cross the river, but they are also found in the piedmont where diabase dikes cut across the Susquehanna. Farther south in the areas of crystalline rock, where the harder rock layers lay athwart the Susquehanna's course, many riffles also occur.

In the riffles south of Harrisburg in the northern section of the piedmont their barrier nature is most pronounced. Here they are formed by the hard diabase dikes that cut across the river at three points, thus creating serious obstacles to river traffic even at high water. These three points occur in a distance of 8 mi. They are known as Middletown Falls, Conewago Falls, and the Haldeman Riffles. All have been serious barriers to navigation in the past (*6*) and their presence has served as a strong point in favor of canal-building interests.

The rock barriers across the river have produced

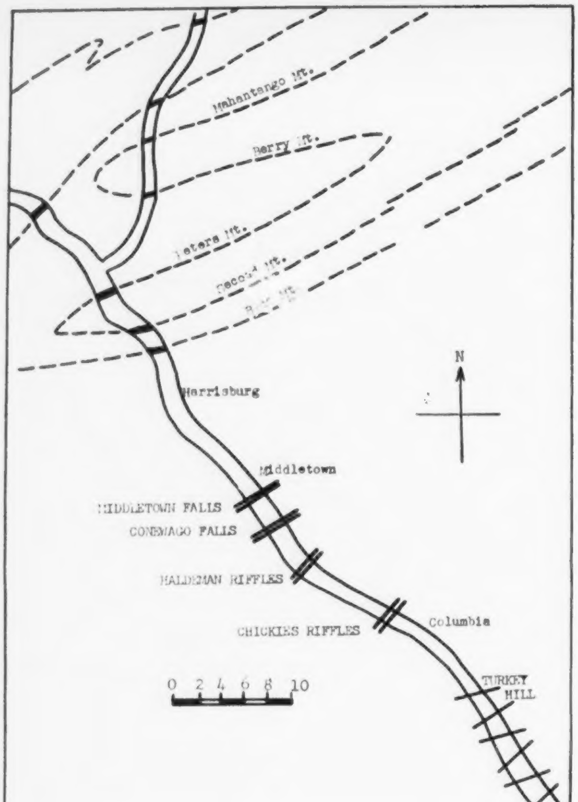


Physiography of the Susquehanna watershed. Scale 1:4,000,000.

three distinct types of riffles. The first type consists of riffles that are relatively narrow, less than 0.2 mi in passage, and they might be more accurately described as low falls. The second type is made up of the riffles that are longer than 0.2 mi and may be called rapids. The third type can be distinguished in the barriers that consist for the most part of islands in the river, connected by ledges of rock that do not offer serious obstacles to river traffic except at low water. The first type is commonly developed in the water gaps above Harrisburg, the second is associated with the dikes crossing the river in the northern piedmont, and the third is best developed in the crystalline highlands below Columbia.

These riffles not only formed barriers to navigation but also created fairly large areas of relatively smooth, deeper, and quiet water impounded behind them. Early ferry sites were commonly located behind the riffles (*7*), which can be noted by checking the ferry crossings with the topographic maps of the valley. These areas of quiet water also became basins of deposition for the coal washed from the anthracite mines up the valley and, accordingly, have become the chief points in the river for the dredging of river coal.

Although the significance of the three major physiographic factors just described outweighed all other physiographic influences, there were a



Riffles in the Susquehanna River. Scale 1:500,000.

number of secondary factors that played less important roles but were of consequence in the utilization of the Susquehanna Valley for transportation. They functioned mostly locally, usually by futhering developments that grew out of the broader over-all pattern of the major factors. These minor factors must therefore be taken into consideration.

Between West Pittston and Tioga Point the Susquehanna follows a channel in which a series of well-entrenched meanders is a prominent feature of the topography. The river flows at right angles to the structural trend of the plateau, causing the meanders to cut deeply into the mountain slopes, thus forming vertical cliffs that rise abruptly from the river, but at the same time creating flood plains in the convex curve of each meander. From crest to crest the width of the river and its plains is nowhere more than 1 mi, but in some places it is so narrow that the valley is almost a gorge. Ten such narrows occur between West Pittston and Tioga Point. These narrows form the only constrictions in the valley, but they are significant because they help to render the Susquehanna passageway inferior to the Mohawk (*3*, p. 442).

The narrows are not long, the longest being less than 1 mi. They were no impediment to canal construction, and at each of the narrows there was room for the railroad. However, they have been obstacles to highway construction, for once occupied by tracks, there was no room left for roads, and as a result the highways have been carried over the hills.

The impediment offered by the narrows is overcome by the vast amount of flat bottom land on the flood plains, and this made the construction of canals and railroads a relatively simple engineering operation. Early travelers through the valley commented on the beauty of these plains lying between the mountains (*8*). One unfavorable aspect should be noted, however, at times of high water the plains are flooded, and occasional interruption of traffic results.

Between Pittston and Nescopeck the Susquehanna flows through the Wyoming Valley. This valley is structurally a syncline of younger rocks folded down into the older formations of the Appalachian Plateau (*9*). From the point where the Susquehanna enters this valley to the point where it leaves, a distance of roughly 16 mi, the width of the valley is not more than 5 mi at any point. It is bordered by even-crested mountains that are broken by gaps and saddles controlling access to or egress from the valley. Distributed over the floor of the valley at the base of the mountains are accumulations of sand, gravel, and clay, and mixtures of all three in varying proportions. These deposits were derived from the detritus of the last glacial ice that covered the region and the streams that discharged from it. They have filled the valley to the depth of many feet and have produced a relatively flat land across which the river has taken its course. The presence of coal in the valley led to intensive urbanization and industrialization, both of which were greatly helped by the flat nature of the land, which allowed expansion.

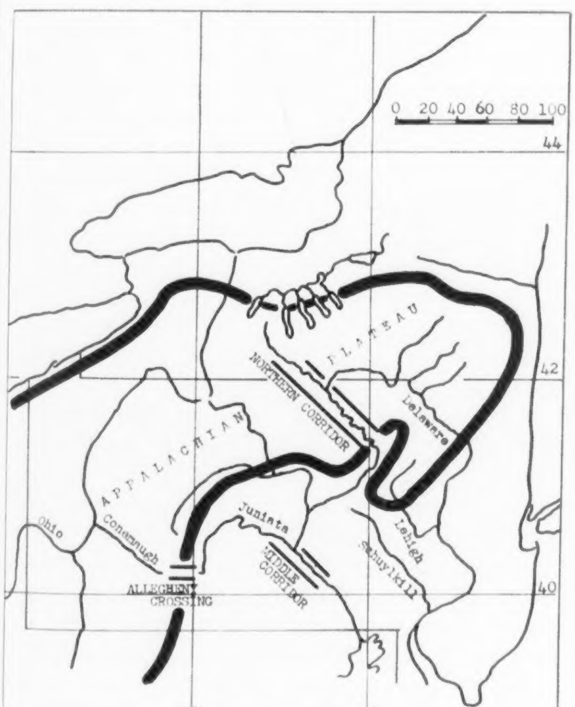
The entry of transportation facilities into the valley was mostly controlled by the gaps and saddles, but once in the valley, canals, railroads, and highways could be carried almost anywhere over the valley floor with ease. Thus it can be seen that the topography of the valley surface greatly aided and in no way seriously hindered the human use of the Wyoming Valley.

Another secondary factor in the development, or in this case in the retardation and lack of development, of transportation facilities in the Susquehanna Valley was the deep gorge in the lower portion of the valley where the river cuts through the crystalline rocks of the piedmont to Chesapeake Bay (*10*). Beginning at the riffles

opposite Turkey Hill a few miles below Columbia, the Susquehanna flows in almost a straight course for 35 mi through a steep-sided valley that has been incised to a depth of from 300 to 600 ft below the summit levels of the surrounding hills. Prior to the construction of hydroelectric power plants, this portion of the river was obstructed by one series of riffles after another. The absence of any large valley flats, plus the precipitous nature of the sides of the valley, made the construction of any roadway paralleling the river a difficult, although not impossible, task. At the same time the riffles made navigation extremely hazardous and discouraged a more complete use of the river itself.

The gorgelike nature of the river valley, although creating topography unfavorable to the building of canals, railroads, or highways along the banks of the river, did not prevent such construction but made it quite difficult. It is significant that no major highway follows this portion of the valley today and that from Safe Harbor to the Chesapeake only a single-track railroad follows the eastern shore. Not even a dirt road parallels the York County side except for a few scant miles below Wrightsville.

On the other hand, this same topography was favorable for locating hydroelectric power-producing plants in the lower Susquehanna Valley (*11*). Unlike other rivers flowing into the Atlantic, the Susquehanna's steepest slopes occur near its mouth. In its passage through the gorge it has a fall of 5.6 ft/mi, as compared with an average fall of only 3.5 ft/mi between Otsego Lake and Columbia. The average fall of the entire river is only 3.7 ft/mi. Thus the greatest potentialities for power generation were concentrated in the last 35 mi of the river. Here also the topography favored the construction of dams across the river. The riffles provided good foundations, and the pounding of water behind dams was aided materially by the depth of the valley. Moreover, the creation of the dams flooded no valuable farm land. It flooded out no large villages. When the first dam was built in 1910 the nearby industrial areas of Baltimore and Philadelphia were the potential markets. Today the industry is expanding to meet the growing demand for kilowatts in the Harrisburg, Lancaster, and York areas as well as in their original outlets at tidewater.



Location of the Susquehanna corridors.
Scale 1:4,000,000.

The term *corridor* has been applied in connection with the Susquehanna Valley in indicating that its "corridor value" was due in part to physiography. It may be well at this point to explain more fully what is meant by these terms and to compare the corridor value of the Susquehanna Valley with that of several other rivers of the Atlantic seaboard.

The term *corridor* indicates a passageway. Any natural passageway across a natural barrier may constitute a corridor in the physical sense, but to possess any value the passageway must do one of two things. It must either connect two regions that can be mutually benefited economically by the use of the corridor or it must open up a region's natural resources to outside markets. Thus there are two kinds of corridors: (i) the through corridor, that connects regions separated by a barrier and (ii) the penetration corridor that opens regions to commercial exploitation without necessarily crossing any natural hindrance to movement.

If a corridor performs either of these two services, it will be used; if not, it will remain unused. Hence the term *corridor* implies utilization. The amount of use a corridor receives depends on its serviceableness, which is determined by a number of local factors. These factors are chiefly as follows.

1) Steepness of grade. The easier the grade, the more readily goods can be transported. Roads can be more easily constructed at easy grades, and a too steep grade can eliminate certain carriers as well as slow down others.

2) Width of passageway. A narrow passageway may constitute a bottleneck and hinder freedom of movement. The wider a passageway at its narrowest point, the less likelihood there is for such

Southern entrance to the northern Susquehanna corridor above West Pittston.

stoppage, and a very wide opening will allow for two-way movement.

3) Straightness of course. A winding passageway increases both the distance and the time of traveling through it. A direct course, on the contrary, accelerates movement.

4) The presence or lack of a navigable river. If water transportation is possible, either by direct use of a river flowing through a corridor or by the utilization of such water for canals, the value of the route is increased greatly, since transportation by water is commonly recognized as less expensive than transportation by land.

5) Seasonal blockades. If the climate is such that a corridor is closed for several months by ice or snow during the winter or waterways are rendered inadequate by long summer drouths, the value of the corridor is decreased proportionately.

6) Political control. If a corridor should pass between two areas under different sovereignties, trade restrictions, such as tariffs, quotas, and so forth, may greatly lessen the corridor's value, if not eliminate it completely.

7) The resources of the regions served. These form the basis of the commerce that will pass through a corridor. They are essential considerations, for without them the value of a corridor is nil, since there would be no service to perform.

Two segments of the Susquehanna Valley are being used intensively as corridors today. One is the portion of the river between West Pittston, Pennsylvania, and Waverly, New York, between which points the river has cut a low passage through the Appalachian Plateau, thus forming, in conjunction with the Chemung Valley and Seneca Lake, a trans-Appalachian passageway (*3*). The other is the segment of the river used by the main line of the Pennsylvania Railroad, where the Susquehanna flows through the first three of the great water gaps north of Harrisburg (*4*). In the strictest sense of the term, this segment of the valley is not a trans-Appalachian passageway, although the railroad that uses it is a trans-Appalachian railroad. The Pennsylvania Railroad crosses the Appalachians, not by following the Susquehanna River, but by carrying its tracks up the Allegheny Front behind Altoona. The gaps of the Susquehanna, however, make it possible for the railroad to penetrate the first barrier ridges to reach an easy route (the Juniata Valley) to the Allegheny Front.

It might be well to examine each of these Susquehanna corridors with respect to the factors of serviceableness just enumerated. Consider first the Susquehanna's trans-Appalachian, or northern, corridor.

The length of this corridor between the Wyoming Valley and Tioga Point is just 60 mi, including all bends. At the junction of the Susquehanna and the Lackawanna rivers, the elevation is 550 ft above tide level. At Tioga Point the elevation is 750 ft above tide level. This gives the river a grade of roughly 3.5 ft/mi.

Throughout the length of the corridor the average width of the valley that the river has cut into the plateau is about ¼ mi. In places, on the

flood plains, it widens out to a little more than 1 mi, but these are exceptions. The valley sides are steep, in many cases precipitous, rising 600 to 700 ft above the floor of the valley, thus confining human movement through the corridor to the valley flats. Its narrowest points are just wide enough to allow limited transportation facilities on land.

In this part of its valley the Susquehanna is a winding river. The incised meanders lengthen the water course considerably. In the more open flats, the highway that roughly parallels the river between West Pittston and Athens follows the sides of the valley and not the windings of the river. In the narrow portions of the valley, however, the highway has been carried over the hills, partly to save miles and partly because the railroad occupied the narrows first. For example, at Wyalusing, U.S. Highway 6 was built over the tops of the hills that rimmed the valley instead of following the river. The Lehigh Valley Railroad, on the other hand, hugs the river's eastern bank. The difference between the railroad and highway distances through the corridor is 6 mi, the railroad having the shorter mileage.

Judged by present-day standards, the portion of the Susquehanna flowing through this corridor is not a navigable river. However, in the past it was used for navigation with some success. Today, however, the river in this area is of no value for transportation.

During the winter months the river here is usually frozen. At times snow blocks the roads but not for long periods. In the past, low water during the summer months greatly impeded the use of the river or prevented the securing of water from the river for use in the canal. On the other hand, in times of high water, the passageway may be completely flooded.

Since the corridor does not cross any international boundaries, no problems of trade restrictions hurt its use today. Even in the decades just prior to 1800 when the political control of the area penetrated by the corridor was in dispute between Pennsylvania and Connecticut, its use was not seriously affected, for its value as a corridor was too great to suffer from political uncertainty.

Resources played a significant role in the utilization of the corridor. Possibly the most important resource was the anthracite of the Wyoming Valley, which has been a basic factor in the development of transportation from the mines to New York State since 1800. Moving in the opposite direction were salt, gypsum, and dairy products to the Wyoming Valley and the Atlantic seaboard beyond (*12*).

Concerning the middle Susquehanna corridor, one may note that its length, between First Mountain (also known as Blue Mountain) and the junction of the Juniata and the Susquehanna, is exactly 8 mi. At the First Mountain the elevation of the river is 300 ft above tide level. At the junction of the two rivers the elevation is 334 ft above the tide level. This gives the Susquehanna an average grade of about 4 ft/mi through its middle passageway.

Throughout the length of this route, the narrowest sections of the passageway are at the three water gaps. At these points the pathway averages slightly more than ½ mi in width and allows space for limited land movement on both sides of the river. Between these gaps the course opens to a maximum width of 3 mi where the river flows parallel to and between Peters Mountain and Second Mountain.

In this short distance the Susquehanna flows through two great curves, one entering the corridor in the gap at Peters Mountain, and the second on turning south to leave the corridor through the gaps in Second Mountain and First Mountain. Between these curves the river follows a relatively straight course for 4 mi.

The Susquehanna River here, as well as farther north, judged by present-day standards, is not navigable. In the past, however, the use of the river for small craft made the middle passageway a major artery of commerce. The greatest impediments to navigation were, and still are, the riffles that lie athwart the course of the river at each of the water gaps.

Ice and snow in winter and low water in sum-

Northern Susquehanna corridor from Wyalusing Rock, looking downstream. The Lehigh Valley Railroad runs along the left side of the river.

mer have been serious impediments to the more complete use of this corridor in the past, although ice and low water are no longer as serious obstacles as snow. The traffic now passing through the corridor is not hampered by the effect of weather conditions on the river. However, floods are always a possible threat to both the railroad and the highway that follow the Susquehanna's banks between Harrisburg and Clark's Ferry. The resources of the immediate area have been of only minor importance in the development of the middle Susquehanna corridor.

For the purpose of pointing out how other corridors that penetrate the Appalachian Highlands from the coastal regions either meet the criterions set forth in the preceding paragraphs or fail to do so and, thus, evaluate more accurately the corridor value of the Susquehanna passageway, four other river valleys are presented for consideration. Each represents a somewhat different situation from the others, and all represent different conditions from those associated with the Susquehanna. These river valleys are those of the Mohawk, Delaware, Lehigh, and Schuylkill rivers.

Perhaps the most cited example of corridor value is that of the Mohawk route. It is commonly used in many geography textbooks in elementary schools, secondary schools, and colleges (*13*). This corridor is a natural trans-Appalachian passageway that gives the port of New York access to the markets of the Middle West via the Great Lakes and their adjoining lowlands. It is a corridor where most of the factors of serviceableness are favorable. The grade is easy. The passage at its narrowest point is wide enough for the Mohawk River, the New York State Barge Canal and its locks, the main line of the New York Central Railroad, and two major highways. Its course is relatively straight, and the regions that it serves have been rich agricultural areas from the very outset of the white man's habitation. As the result of the development of the corridor as a passageway, major industrial areas have grown up within it and adjacent to it. Politically it is wholly within the control of New York State. The only unfavorable factor has been the severe winters which in the past, and even today, either completely blocked movement through the corridors or greatly impeded traffic.

Because of the extremely favorable serviceableness of the Mohawk corridor, from the time the Erie Canal was opened in 1825, the connected regions began to reap rich economic benefits through its utilization, and they have continued to do so ever since. The Erie Canal opened a period of unprecedented prosperity to a large portion of the United States. The Great Lakes and their hinterland of the old Northwest were firmly united with the port of New York via the Mohawk gateway, for through it the distance to the sea was shorter than either the Mississippi or the St. Lawrence routes.

A completely different situation is noted in the Delaware Valley. Here no busy throughway has developed. This has not been because of unfavorable local factors of serviceableness but rather because the Delaware Valley, unlike the Mohawk Valley, is not a trans-Appalachian route. It does not even connect two regions between which there might be an exchange of commodities to any great extent. Economically and geographically, the Delaware Valley might well be considered a dead end. There is no railroad paralleling the river from its source to its mouth. There never has been a canal the entire length of the river. Both rail and waterways have used only small segments of the valley.

On the other hand, the valley of the Lehigh River in Pennsylvania has developed into a corridor of major importance, largely because it made possible the opening of the anthracite fields around Mauch Chunk (now renamed Jim Thorpe) to the Philadelphia and New York markets a century ago, and some decades later it performed a similar service for the cement industry of Northampton and Lehigh counties. As early as 1829 a canal was dug between Easton and Mauch Chunk. By the mid-century railroads followed. Today three railroads use the valley, and it is well served with modern highways.

The engineering achievement of carrying the railroads over the divide into the Wyoming Valley, thus linking the valley of the Lehigh River with the upper Susquehanna and giving it a share in the trans-Appalachian traffic, came after the original impetus had made itself felt and must be considered as a secondary factor as far as the importance of the Lehigh River Valley is concerned. It did not play as much of a part in the growth of the valley's industrial centers as did the resources of the upper valley and the accessibility of the valley to New York and Philadelphia. It has, however, made the valley of the Lehigh River a minor link in the trans-Appalachian route of the Susquehanna.

The Schuylkill River flows from the lower anthracite fields in the vicinity of Pottsville, south to meet the Delaware River below Philadelphia at tidewater. It therefore offers a route through which coal from the southern anthracite field has been moved to the Philadelphia market for more than a century. Canal, railroad, and modern highways have followed the Schuylkill Valley through its en-

The middle Susquehanna corridor. View from the West shore, ½ mi downstream from the mouth of Cove Creek looking toward Dauphin. Note the riffles in the river. The tracks of the Pennsylvania Railroad are in the foreground.

tire length, for the factors of serviceableness are excellent. However, other factors have prevented a through corridor from developing. The mountains north of Pottsville and the river's headwaters make a formidable barrier so that no main-line communication exists between the upper Schuylkill and points beyond.

In comparing all these corridors with the corridor of the Susquehanna, one finds that two of them, the Lehigh and the Schuylkill, were essentially outlets for one commodity, anthracite. Their whole early corridor economy revolved around this basic commodity, as have the economics of the upper portions of the areas that they served. They penetrated areas but did not pass through them. It is probable that these corridors would not have been so intensively developed had the anthracite not been present.

On the other hand, the Susquehanna also played a major role in the exploitation of anthracite (in the Wyoming Valley), but coal was not the sole factor in the use of the Susquehanna corridors. Lumbering also played a major role, as did other products, such as iron, steel, dairy products. The fact remains that the Susquehanna offered a route across the Appalachian barrier. In this respect the Lehigh and the Schuylkill failed.

With regard to the Delaware corridor, no comparison needs to be made. It was introduced to show that the factors of serviceableness are not enough to create a corridor out of a passageway.

The Susquehanna, however, differs greatly as a corridor from the Mohawk. The trans-Appalachian aspect of the Susquehanna applies only to a small segment of the whole valley, whereas in the case of the Mohawk the entire valley forms the passageway.

Taken as a whole, the Susquehanna Valley served as a north-south corridor, while the Mohawk Valley has always been primarily an east-west route. Because of this, the Mohawk is able to perform far greater services, since it connects more important economic areas and serves a hinterland of much greater magnitude than the Susquehanna.

The Mohawk passage has maintained and increased its corridor value from the time it was first used by the white man, whereas the corridor value of the Susquehanna has fluctuated greatly over the centuries.

This leads us to the consideration that the value of a natural passageway is never fixed. It may change from time to time and from place to place. In the case of the Susquehanna, there was a time when the corridor value of the lower river as a highway was of enormous importance to the economy of the region (*17*). Today this is no longer the case. On the other hand, the corridor value of the short stretch between Harrisburg and the mouth of the Juniata River has risen to tremendous importance as the main line of the Pennsylvania Railroad. Such changes may be attributed to one or more of a number of factors, all of which have influenced changes that took place in the Susquehanna Valley.

Frequently a corridor is employed heavily as an outlet for a resource that has become a basic com-

modity of the area. In time this resource becomes exhausted, and the route ceases to function as an important outlet for this commodity. In our consideration of the Susquehanna Valley, the decline of the lumber industry is a case in point.

For many reasons whole populations shift from time to time, moving completely out of one region into another, thus creating or destroying markets in the regions affected and exerting strong influences on the value of any corridors serving the area. Thus the gradual shift westward of the Indian population from the Susquehanna Valley led to a decline of its importance as a corridor in the fur trade. On the other hand, the influx of New Englanders into the devastated upper Susquehanna Valley at the conclusion of the American Revolution was in part responsible for the first intensive commercial use of the northern corridor, a use that has continued steadily until today.

As the population of a region increases through normal growth, its markets increase proportionately. This in turn will call for a more intensive use of transportation facilities to serve the growing region, and natural pathways offering entrance or egress will consequently become more and more important. Thus, as the population increased in the lower valley during the 18th century, as well as in the metropolitan centers of Philadelphia and Baltimore, the amount of commerce moving down the valley to these centers increased.

The ability to develop new and better means of transportation will transform a corridor that has previously been of little use into a busy and important commercial highway. In the case of the northern Susquehanna corridor, its use was limited as long as the river alone was the highway, but as canals were dug and railroads were built through it, its value increased with each additional advancement in transportation facilities. The development of the automobile and construction of modern highway facilities have led to a more intensive use of this portion of the valley than ever before.

Most of the technologic advancements in transportation would have been useless without engineering skill to create their rights of way. The digging of the early 19th century canals and the construction of their locks were major engineering triumphs. The laying of railroads and the building of modern highways are achievements of engineers, without which the corridor value of the Susquehanna would be far less than it is today.

Sometimes a corridor, or a portion of it, may be of great value to certain interests in gaining their ends, owing to temporary conditions brought about because of strategic position in wartime. Thus, the Susquehanna passageway above the Wyoming Valley performed an important service during the Revolutionary War by furnishing General Sullivan with a route of penetration into the heart of the Iroquois country in 1779. This made possible his crushing blow to the Indian-British warfare on the frontier.

Political conditions can do much to enhance or impede the value of a corridor. Although this was a minor factor in the fluctuation of corridor value in the Susquehanna Valley, one example might be cited. In the late 18th century the Pennsylvania legislature passed laws forbidding improvements in the channel of the river below Columbia in order to prevent commerce from moving below that point to Baltimore, and thus to encourage its movement overland to Philadelphia.

Sometimes the development of a second corridor can threaten the value of the first; however, it does not always follow that such will be the case. Often a second corridor will supplement the other, if the use warrants. The Susquehanna northern corridor has been described as supplementary to the Mohawk. It has at no time threatened to supersede the New York route if the Susquehanna corridor had not been available.

Earthquakes, floods, and similar violences of nature may completely ruin the serviceableness of a natural passageway for a long time, and, in rare intervals, permanently. Although the use of lumbering rafts was already on the decline because of dwindling forests, it was the great flood of 1889 that brought about the end of this one-time important means of bringing lumber down the river.

Thus, over a long period of time great changes take place in the economics of different regions, and this in turn has a direct bearing on the value of the corridors connecting or serving them. Many of the conditions just described as factors in shifting corridor value can be attributed to the passing of time. It may take a few years, or it may take a few generations, to exhaust a resource or completely to settle a region. In the days of simple frontier economy, when the Susquehanna River was used by small craft and its valley was followed only by men on foot or on horseback, the Susquehanna passageway functioned as the major inland corridor between the Chesapeake country in the south and the Ontario plains and the St. Lawrence Valley in the north. It was the important link between tidewater Maryland and Virginia, and Canada. It continued to function in a north-south capacity well into the last century. Gradually, however, this changed. The physical conditions did not change, but the direction of corridor utilization became completely re-

versed. Today two segments of the Susquehanna Valley offer passageway to east-west traffic. The reasons for this change lie not in the physiography of the Susquehanna country, but in factors of an entirely different nature.

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ASSOCIATION AFFAIRS

AAAS Sections Call for Papers for the Atlanta Meeting

Eleven sections of the Association will arrange sessions for contributed papers at the Atlanta Meeting 26–31 Dec. 1955. The secretaries to whom titles and brief abstracts should be sent, *not later than 30 Sept. 1955*, follow:

C—**Chemistry.** Dr. Ed. F. Degering, 26 Robinhood Road, Natick, Mass.

D—**Astronomy.** Dr. Frank K. Edmondson, Goethe Link Observatory, Indiana University, Bloomington, Ind.

E—**Geology and Geography.** Dr. Robert L. Nichols, Department of Geology, Tufts College, Medford, Mass.

F—**Zoological Sciences.** (If outside the scope of the American Society of Parasitologists and the Society of Systematic Zoology, which are meeting with the AAAS.) Dr. Harold H. Plough, Department of Biology, Amherst College, Amherst, Mass.

G—**Botanical Sciences.** (If outside the scope of the American Phytopathological Society, which is meeting with the AAAS.) Dr. Barry Commoner, Henry Shaw School of Botany, Washington University, St. Louis, Mo.

I—**Psychology.** Dr. William D. Neff, Department of Psychology, University of Chicago, Chicago, Ill.

L—**History and Philosophy of Science.** Dr. Jane M. Oppenheimer, Department of Biology, Bryn Mawr College, Bryn Mawer, Pa.

Nd—**Dentistry.** Dr. Russell W. Bunting, School of Dentistry, University of Michigan, Ann Arbor.

Np—**Pharmacy.** Dr. John E. Christian, School of Pharmacy, Purdue University, Lafayette, Ind.

Q—**Education.** Dr. Dean A. Worcester, University of Nebraska, Lincoln.

New Section Officers

As authorized by the Council of the AAAS at its meeting in Berkeley last December, the Board of Directors on 20 Mar. approved the nominations of two of the Association's sections, as follows:

Vice president and chairman of Section N—Medical Sciences: S. E. Luria, professor of bacteriology, University of Illinois.

Vice president and chairman of Section P—Industrial Science: Earle L. Rauber, vice president and director of research, Federal Reserve Bank, Atlanta.

The following section secretaries were appointed:

Section E—Geology and Geography: Robert L. Nichols, Henry Bromfield-Pearson professor of natural science and geology, Tufts College.

Section L—History and Philosophy of Science: Jane M. Oppenheimer, professor of biology, Bryn Mawr College.

SCIENCE ON THE MARCH

SAVING THE FORESTS

OUT of the cry of the late 1800's "Save the forests," the Forest Service emerged in 1905. Of its original 734 members, 466 were field men who, through civil-service examinations, had been selected for their ability to do just that.

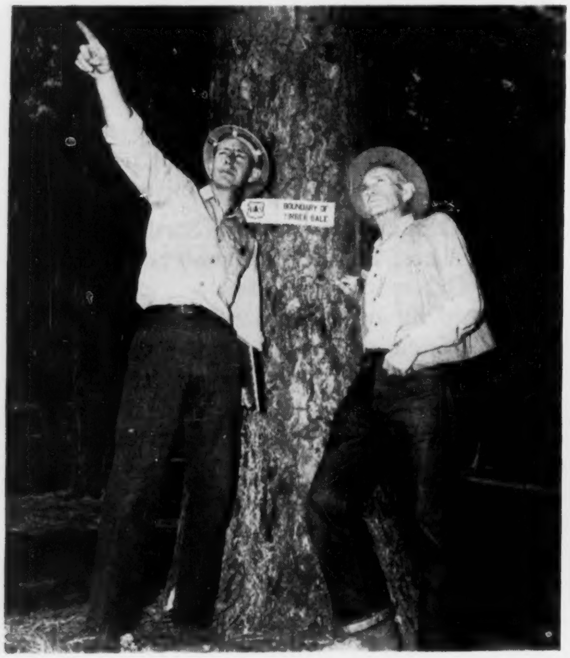
They had demonstrated their ability to ride, pack, and care for a horse. They had showed their skill with a gun and their skill in keeping a straight course in the woods. They had made sourdough and had eaten the biscuits they made from it. Thus, they had proved that they could take care of themselves and the forests they were to guard.

These men went about saving the forests in the ways that were known at the time. They fought fire with shovel and axe, sometimes all alone, after traveling miles on horseback. They surveyed boundary lines. They regulated the use of forest timber and grazing land—no mean task because the national forests had been carved from the old public domain that had always been open to free use.

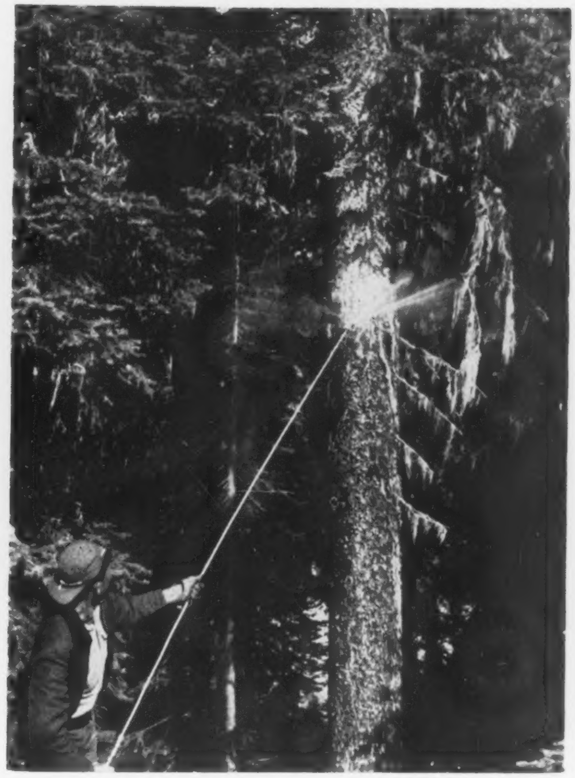
While the field men were literally saving the forests during the first 10 years of the Forest Service's existence, a handful of professional foresters were also laying solid foundations in forest conservation. Forestry schools were expanding. Men technically trained in managing trees like a crop would soon apply their know-how to federal, state, and privately owned lands.

Congress passed the Weeks Law that started federal-state cooperative work in forest-fire control. The Forest Service set up an experiment station in the Southwest for range and water research. It also established the Forest Products Laboratory at Madison, Wisconsin, to work on better and more complete utilization of wood and wood products.

By the end of the first decade forestry was here to stay. Between 1915 and 1924 conservation organizations sprang up to give it an additional boost: Association of State Foresters, Izaak Walton League, and National Parks Association. The Society of American Foresters and the American Forestry Association had already been founded. The Clarke-McNary Act of 1924 extended the state and federal cooperative program in fire pro-



(Left). Timber sale officer going over the timber sale area with a company forester. The Forest Service does not do any logging itself. The timber is sold to the company making the highest bid, and, under contract, the successful company logs the area under the supervision of the forest ranger or his timber sale representative. (Right). Two smoke jumpers descending to a small fire. The orange and white candy-striped chute has become standard equipment because it is more easily seen on the ground. [All photos courtesy U.S. Forest Service]



(Top, left). In order to study the vegetation, a two-man crew chart a meter-square quadrant with a pantograph. (Bottom, left). The response of trees to treatments designed to increase growth is measured in a number of ways. Here the evidence comes from a study of tree rings. (Right). The functions of the Forest Service include the fight against insects and disease. Here a deflector is being used.

tection and added distribution of seedlings for planting and on-the-ground technical assistance to small woodland owners. In California, the U.S. Army under Hap Arnold flew planes for forest-fire patrol.

The highlight of the third decade was the depression that brought into existence the Civilian Conservation Corps. Before this corps was disbanded in 1941 they had planted 2,356,000,000 trees, built 126,000 miles of trails and minor roads, constructed 89,000 miles of telephone lines, built 6,660,000 erosion-control check dams, put in 6,459,000 days fighting fires, and controlled tree and plant diseases and insect infestations on 21 million acres.

The period 1935–44 was the era of projects. Some 18,000 miles of shelter belts were planted to tame the wind on the Great Plains, thus helping to control soil erosion. The windbreaks saved many cattle during the blizzards of 1949. When New England had a hurricane, the Forest Service headed a project to salvage the down timber. With World War II came the wood-for-war project known as Timber Production War Project. The naval-stores industry was put on its feet with a conservation program.

Thus, the background was laid for the peak reached during the past 10 years. Organized forest-fire protection has spread from publicly owned land to include some 374 million acres of private land. Tree planting has hit a record high. More timber is being harvested from national forests than ever before.

Forestry schools turn out 1000 foresters each year. The largest single employer of these trained men is still the Forest Service, but states, cities, schools, and trade associations now hire a larger number. Industries employ some 5000 to manage their forests.

Today's federal foresters are all forestry-school graduates who have passed professional examinations. They, too, are saving the forests in the best methods known today: wise use, research, and cooperation with state agencies and private land owners.

DOROTHY M. MARTIN
Forest Service, U.S. Department of Agriculture

BOOK REVIEWS

Tobatí: Paraguayan Town. Elman R. Service and Helen S. Service. Univ. of Chicago Press, Chicago, 1954. xxix + 337 pp. Illus. + plates. $7.

THE senior author is an anthropologist now teaching at the University of Michigan. Mrs. Service, who has also had comprehensive anthropologic training, is administrative secretary of the Society for the Psychological Study of Social Issues, a division of the American Psychological Association. Their book is based on field research conducted in Paraguay during 1948–49 under the auspices of the Social Science Research Council and the Columbia University Council for Research in the Social Sciences. The book may be characterized as a descriptive community study, but it also has additional significance as a contribution toward the understanding of modern Paraguayan culture as a whole. In particular, it has the distinction of being the first anthropologic study of modern Paraguay.

As Julian Steward states in his foreword, one of the chief contributions of this study is that it serves to dispel the myth that the Paraguayans are essentially a Guaraní Indian people and that their culture is derived from the aboriginal Indians. The Services have established that the people living in the nuclear portion of Paraguay surrounding Asuncíon are thoroughly Hispanic in culture, notwithstanding the prevalent use of the Guaraní language instead of Spanish. The only Indians to be found in modern Paraguay inhabit the arid Chaco region of western Paraguay, but do not participate in the national Hispanic culture established in colonial times. The "Guaraní myth," it appears, has been fostered by the literate Paraguayans themselves in the interests of cultural and political nationalism.

The approach followed by the Services reflects in its essentials the social anthropology and methodology of Steward under whom they studied. The book is divided into three sections dealing with the economy, society, and ideology of Tobatí and its environs. It is thorough with respect to general social and economic institutions but provides little information or insight into psychological and ethical data, such as personality and ethos. This limitation is a reflection of their "superorganic" approach to culture, and it is not entirely explained either by the fact that the authors had no collaborators or by the fact that the authors spent only 7 months in Tobatí, a town with a population of 1368.

The general picture presented of Paraguay is that of a peasant culture with comparatively limited range and variation. Social distinctions correspond to slight status differences rather than to sharply defined classes. The comparative weakness of Paraguayan social structure is attributed to the absence of a well-developed national economy and to the predominance of a subsistence-and-cash peasant economy. Thus, the backwardness of the economy, together with the weakness of the Catholic Church in Paraguay, is linked up with the prevalence of "consensual marriage" rather than ritual church marriages. The culture as a whole is said to be Hispanic in the importance attached to male virility and to *compadrazgo*, or coparent relationships. A cult of saints rather than masses and church rituals constitute local, community-level religion. "Paraguay is poor and the plight of the peasant is merely the rural reflection of that fact." The peasants are not interested in politics, but the townsmen are inclined to factionalism.

This intensive, functional, community-type of study is, as the authors recognize, no substitute for the sociologic or economic survey, but it does serve to point up the degree of integration of Paraguayan institutional life. *Tobatí* is a solid, informative, pilot study by two competent, promising anthropologists, and it should further our knowledge of a much-neglected segment of Latin-American culture.

DAVID BIDNEY
Department of Anthropology, Indiana University

The Mathematical Practitioners of Tudor and Stuart England. E. G. R. Taylor. With a foreward by the Astronomer Royal, H. Spencer Jones. Cambridge Univ. Press, New York, 1954 (for the Institute of Navigation). xi + 443 pp. Illus. + plates. $9.50.

THE value of mathematics for practical life is nowadays taken for granted. So it is startling to read that John Newton, an older contemporary of the great Isaac, remarked as late as 1677 that he had never heard of any grammar school in England in which mathematics (even simple arithmetic) was taught. Yet the progress of navigation, surveying, gunnery, and clockmaking during the years covered by the present book, namely, 1485–1714, made it necessary that practical men get some training in mathematics. Instruction that could not be obtained in school was provided, although perhaps inadequately, by the mathematical practitioners of London—by the instrument makers, engravers, and the like—whose art necessarily involved the practice of some mathematics.

This book is an account of such men. It is divided into three approximately equal parts: narrative; biographies; works. The first part gives a straightforward description, in language suitable for the general reader, of the development of mathematical ideas, methods, and instruments in the hands of the practitioners; the other two parts provide the student of history with detailed information and references. A great deal of information is presented, yet it is arranged in such a logical way and written with such fine literary style that the reader's interest will rarely flag. In fact, in the passages on navigation, he may even be reminded of some of the great English novels about the sea. In both content and style the book is an important contribution to the history of science.

S. H. GOULD
Department of Mathematics, Purdue University

Fresh Water from the Ocean. Cecil B. Ellis. Ronald Press, New York, 1954. xi + 217 pp. Illus. $5.

THE Conservation Foundation sponsored this highly vital investigation "to advance knowledge on a matter of obvious public interest." Future development of the arid South and Southwest cannot progress without desalting the ocean to produce streams of fresh water for ever-increasing streams of sun-hungry settlers.

The subject is very "fluid" at the present time. New research activities are being sponsored by the saline water program of the Department of the Interior.

Will it be possible to desalt the ocean on a gigantic scale? How much will this cost in initial investment and in operating costs? To find the answer, Ellis visited most of the laboratories where work is in progress. Finding only two of the proposed methods in actual use, and most of them in the laboratory stage or on paper, he proceeded by extrapolating the present limited knowledge to a gigantic scale of 1000 million gallons of fresh water daily. This is the amount of water consumed daily by New York and vicinity. Visualization of such a tremendous plant is therefore premature.

Scientists and engineers may have been helped considerably by a more technical presentation of the scattered experimental results and economic facts. A sample of the Ellis treatment is enlightening:

> Almost all of the material which is dissolved and invisibile within the sea water occurs in the form of . . . separate ions. Some kinds of ions carry negative electric charges, while the remainder carry positive charges. The total amounts of positive and negative charge . . . are equal, of course, since the solution as a whole is electrically neutral. Putting your hand in the ocean does not give you an electric shock.

This explanation may not help the layman much, whereas it is bound to give a slight shock to the scientist. The unattainable minimum energy needed for desalting sea water is 2.6 kw hr of electrical energy for each 1000 gal of fresh water. Ellis would favor 20–40 kw hr although he does not analyze the present costs of water, which differ greatly in various locations. The maze of initial investment costs and durability remain unresolved.

The book summarizes what has been accomplished. *Multiple-effect fuel-operated distilling plants* have been used for years in the Caribbean area and recently in Kuwait, Arabia. Extrapolating from existing data, the author deems their cost of operation is about 10 times too high. Actual initial cost and operating cost figures could doubtless have been obtainable to corroborate this statement.

Compression distillation is another method that has been used extensively during and since the war to produce fresh water from the ocean on ships and on islands lacking water. Owing to unsolved problems, such as scale formation and corrosion and the limited life of such units, they do not appear to offer much hope either.

The electric membrane methods are discussed at great length. Although this method has been proposed and was used some 30 years ago, recent improvements in electric membranes appear promising. It might have been interesting to read a summary of these technical efforts. Ellis projects a utopian outline of a very large installation with an "admitted guess" cost of $300 million.

Heat from the sun for distilling water is mentioned as another possibility, eliminating all fuel costs. Ellis feels that this method would prove "too unwieldy," although admittedly very little effort has been made in this field and the greatest need for water is under the most broiling sun. The author reviews and interprets numerous other methods, ranging from atomic power to ultrasonics. Practically all the physical forces and some of the chemical methods have been suggested or suspected as being of potential use, in changing salt water into fresh. Schematic illustrations are clear and understandable. What can be done with the salts? Most of the proposed processes do not attempt to accumulate salts from sea water. One single installation (of the 1000 million gallon a day type) would produce several times the salts needed in the United States.

It might have been interesting to learn more about the comparable present cost of water in various locations here and abroad. "Ocean-to-fresh" water works will not start at the gigantic level, but should be preceded by smaller installations in regions where water is now very expensive or not obtainable at all.

The water problem is a long-range one. It is the key problem of man's existence.

MARIA TELKES
College of Engineering, New York University

Archaeology in the Field. O. G. S. Crawford. Praeger, New York, 1953. 280 pp. Illus. + plates. $8.50.

THIS book is an excellent presentation of the practice and results of a division of archeology that might, in this country, be called a field survey. Crawford is a leading exponent of what he regards as a peculiarly British form of sport and of making constructive the effort and pleasure in the British compulsion for walking in the country. But, as he points out,

> If something is not done soon there will be very few [field archeologists] left, in a decade or so, and [they] will be driven into exile by the vandals of their own nation.

Crawford says that archeology is concerned with culture, with "the past tense of anthropology," and with "culture traits as a separate and distinct class of phenomena, which can be explained in terms of culture." For interpretations and evaluations of field and excavation data, the author emphasizes the importance of an anthropologic background and firsthand familiarity with the motor and behavior patterns of peoples living in cultural stages equivalent to the stage of the site that the archeologist is attempting to reconstruct.

There is a brief review of the development of archeology, of the importance of adequate maps, of the debt of archeology to air photography, geology, paleobotany, and other sciences. The main part of the book is de-

voted to examples of the methods of field archeology in discovering, describing, and interpreting surface features resulting from man's occupancy of an area. These remains range from remote prehistoric features to medieval construction banks. Naturally, most of the examples of the fieldwork are from Britain, but there are also discussions of the results of field archeology in Africa, Asia, and the Americas, with valuable suggestions on problems and procedures.

Although it is probably true that the British Isles and the Continent have a much greater variety of surface remains than North America, the procedures and results of field archeology, as presented by Crawford, could be extensively employed here. If a significant number of the thousands of ardent amateur archeologists would follow Crawford's precepts, a large body of significant data could be gathered without the destruction of prehistoric remains.

An all too brief appendix is devoted to "Crankeries," the fantasies of the untrained, and the "axe grinders" whose "evidence" is usually based on years of "close study of the subject." I admire Crawford's statements on such writings:

> The late Mr. Watkin's theories, set out in his book, *The Old Straight Track,* were based upon a misconception of primitive society and supported by no evidence. His writings on the subject are quite valueless.

Archaeology from the Earth. Mortimer Wheeler. Oxford Univ. Press, New York–London, 1954. xi + 221 pp. Illus. + plates. $4.

THE methods and principles of archeology with which Wheeler has become familiar during an unusually active, varied, and fruitful career from Britain to India are presented in this book. Although its scope as a manual is thus somewhat limited, its wide coverage reflects the author's exceptional abilities and experience. His connecting theme is

> . . . an insistence that the archaeologist is digging up, not things, but people. . . . Dead archaeology is the driest dust that blows.

This book is primarily a presentation of the manner in which archeological evidence is obtained. As such, it represents some of the best techniques of the "British" school of archeology. It is principally concerned with obtaining archeological evidence, not with interpreting it. Wheeler assumes that the pursuit of archeology is a justifiable human endeavor, and he regards this assumption as rather evident.

A brief "historical" chapter provides insight into the development of field techniques for some 100 years, which has significant parallels in the study of American prehistory. Comments on excavation standards in the Near East and Eastern fields indicate the profound difference in outlook and training between scholars interested in antiquities and the controlled scientific collection of evidence for the reconstruction of ancient cultures.

There is proper emphasis on the importance of chronology and of careful stratigraphic work to that end. The error of excavating by mechanical levels is emphasized and the importance of well-drawn cross-section diagrams is illustrated.

Separate chapters are devoted to excavation layout, excavation of structures, town sites, and burials. Other chapters are devoted to certain more detailed excavation procedures, to tactics and strategy, to the composition and organization of the staff, selection of tools, field analysis, cataloging, the organization of a field laboratory, photography, publication, and publicity.

This book is one of the better expositions of the technique of gathering basic data for the interpretation of man's past cultures. It can be read with profit by those interested in a clear, uncluttered statement of what archeologists do, and it will be of considerable value to archeologists who can compare their own approach and practice with that of Wheeler.

To too many people, archeology is only a romantic, thrilling way to immortalize oneself or a way to be entertained through life by adventurous trips to foreign lands. There is little of either attitude in this volume. Although admittedly out of context, I cannot refrain from one quotation.

> Avoid any semblance of excitement when an object of some special distinction first begins to emerge. I have seen a director of excavations leap excitedly into a trench on such an occasion, communicating a false and emotional atmosphere to the incident and interfering therefore with cool objective workmanship. It is essential to check any sort of excitement instantly, and to insist firmly on quiet routine.

JAMES B. GRIFFIN

Museum of Anthropology, University of Michigan

Archaeopteryx lithographica. A study based upon the British Museum specimen. Gavin de Beer. British Museum (Natural History), London, 1954. xi + 68 pp. Illus. + plates. £2.

TWO of the rarest and most significant fossils in the world are the two skeletons of *Archaeopteryx.* One has been preserved for many years in the Berlin Museum, the other in the British Museum. In a new monograph, Gavin de Beer, director of the British Museum (Natural History), presents a detailed study of the London specimen. Both of these specimens have been the subject of intensive studies in the past, and one would suppose that there is little new that could be said about them. Nevertheless, the author has produced an important contribution to the field of paleontology and evolution, partly because he has carried out his work with great thoroughness, partly because he has benefited from modern techniques of preparation and lighting, and partly because he has made a careful, objective interpretation of the precious fossil that forms the subject of his study.

He shows that *Archaeopteryx* is characterized by a mixture of primitive, thoroughly reptilian characters and of advanced, thoroughly avian characters. Among the former are such features as the long, bony tail, the comparatively simple vertebrae, the lack of pneuma-

ticity in the bones, the presence of teeth in the jaws, the free metacarpals, the simple ribs, and the reptilian-like brain. Among the avian characters are the elongated and backwardly directed pubis, the presence of a furcula or "wishbone," the adaptation of the foot for perching, and above all, the presence of feathers. De Beer stresses the fact, emphasized in earlier work on primitive reptiles by D. M. S. Watson, and aptly illustrated by *Archaeopteryx lithographica*, that transitional forms between major categories of animals generally show a mosaic of characters, some of which are typical of the ancestral group and some of which are typical of the new group that is arising.

The author considers the origin of flight and concludes that *Archaeopteryx* arose from "pro-avis" ancestors that glided from one tree to another. He concludes by showing that all evidence favors the inclusion of both known specimens of this first bird in a single genus and species.

EDWIN H. COLBERT
Department of Geology and Paleontology, American Museum of Natural History

General Education: Explorations in Evaluation. The final report of the Cooperative Study of Evaluation in General Education of the American Council on Education. Paul L. Dressel, Director. American Council on Education, Washington, D. C., 1954. xxiii + 302 p. $3.50.

WHAT we should all like to know is whether general education is more successful in achieving certain of the objectives of higher education than the traditional approach it has replaced at many colleges. Dressel's study does not attempt to answer this question. "Practically speaking," he says, "this is an impossible task and certainly an unprofitable one." He chose a more profitable but scarcely less difficult goal. He set out with the assumption that there was enough agreement on the ends of general education to warrant an attempt to find out whether some means to these ends are better than others. Whether he succeeded in reaching even this limited goal is debatable, although some of his evidence suggested to him that he was on the right track. On the way, he and his fellow-explorers from 19 colleges constructed some 18 respectable tests or forms of tests in science, social science, communications, the humanities, critical thinking, and attitudes, and three instructional handbooks that will enable others to carry on. They also learned a lot about evaluation, about the attitudes of teachers toward evaluation, and about the relationship of evaluation to instruction.

The common objective of general education accepted by the six committees that prepared the tests was the improvement of critical thinking. The tests are essentially tests of critical thinking.

The results of experimental adminstrations of the tests were inconclusive. Posttest results showed higher intercorrelations than pretest results. Dressel interprets this as proof that students in general-education programs do learn to think critically about a variety of problems and to perform more consistently over a wide variety of tasks. But the higher intercorrelations of the posttest results may only have been the familiar regression toward the mean. Another puzzling finding was the fact that students who made the highest pretest scores made the smallest posttest gains. This may also be attributable to regression, or it may suggest that students who have a developed capacity for critical thinking when they enter college gain little from further training in critical thinking and might better spend their time learning something to think about. Analysis of the pretest and posttest results suggests that, insofar as critical thinking is concerned, general-education programs are most helpful to the student whose critical thinking is not well developed, and they are most successful in colleges where general education is believed in by the faculty, supported by the administration, and backed by evaluation.

Whatever influence the study may have will depend on the circulation of Dressel's report, the distribution of the tests, which are in the hands of the Educational Testing Service, and the interest in the instructional handbooks, published by the William C. Brown Co. of Dubuque, Iowa. The colleges that participated in the study are not the ones that have been most influential in the spread of general education, such as Columbia, Harvard (which was, however, represented on the Committee on Tests and Measurements), and the University of Chicago. Perhaps the nonparticipation of these and similar colleges stemmed from the prevalent attitude of many teachers that whatever is worth measuring, is *ipso facto*, immeasurable. Perhaps it also stemmed from the necessity, inherent in any cooperative study, to de-emphasize the content of education, since the common ground is so small, in favor of critical thinking. Many teachers are deathly afraid that this approach will lead to the development of what Edward Chamberlain of Dartmouth has called, in another context, "the well-rounded man with the short radius."

WILLIAM C. FELS
College Entrance Examination Board, New York

Motivation and Personality. A. H. Maslow. Harper, New York, 1954. xiv + 411 pp. $4.50.

THIS is a challenging, provocative, and skillfully presented statement of the general systematic approach to personality evolved by A. H. Maslow during the past two decades. Some of the material is not new, having been published elsewhere in learned journals, although here for the first time it is assembled in a single organized volume.

The systematic view of personality presented by this author constitutes a major departure from tradition. It is a thoroughgoing protest against both behavioristic reductionism and orthodox Freudianism. The former is rejected for its failure to recognize the emergence of higher human motives and for its derivation of adult behavior from the biological concept of homeostasis. The second is criticized because "the study of cripples,

stunted, immature, and unhealthy specimens can yield only a cripple psychology and a cripple philosophy." In contrast, he leagues himself with those who "postulate some positive growth tendency in the organism which from within drives it to fuller development."

Among the more challenging articles of Maslow's position are the following: that instinctive human needs include the need for cognitive development, self-actualization, and other needs traditionally viewed as derived; that gratification of "lower" needs permits the emergence of these "higher" needs; that threat to the self and not frustration per se is the root of neurosis; that all behavior should not be considered as motivated, especially "expressive behavior"; that the distinction between conation and cognition is spurious; that at the highest level of psychological health there emerges the self-actualizing personality characterized by easy acceptance of self and the world, spontaneity, detachment, independence of cultural coercion, social compassion, and a rich appreciation of art and certain aspects of religious experience.

Emerging from these and other doctrines is a vision of human personality essentially joyous and optimistic in temper. The "self-actualizing personality" provides a relieving complement to the dreary accounts of human conflict, frustration, and misery which constitute so much of the substance of traditional and especially Freudian lore. But critics of Maslow's concept will doubtless contend that his views are better argued than proved and others, more unkind, that much of what he says is better poetry than science. Many will regret that he did not find the opportunity, as he states, to include chapters on the problems of discipline, harmful permissiveness, and the effects of frustration, conflict, and deprivation which would provide a fuller and more balanced picture of his views.

ROBERT H. KNAPP
Department of Psychology, Wesleyan University

Time Distortion in Hypnosis. An experimental and clinical investigation. Linn F. Cooper and Milton H. Erickson. Williams & Wilkins, Baltimore, Md., 1954. ix + 191 pp. Illus. $4.

IN a historical light, this book becomes an important contribution to hyponosis literature, since it is a study of the first new hypnotic phenomenon discovered in well over 100 years, everything else having been reported by about 1830.

The specific technique that has been developed by the authors furthur enhances the potential usefulness of hypnosis methodology to psychology and medicine. It is interesting to note that this phenomenon, called *time distortion,* occurs spontaneously in many hypnotized subjects, but its observation and explanation by those who use hyponosis had been either completely bypassed or limited to conjecture only, until Linn Cooper began his detailed scientific investigation in 1948.

Part I contains Cooper's original detailed plan with the experimental data to substantiate his concept. In part II, his collaborator, Milton Erickson, a leading authority in hypnotic techniques and research, confirms Cooper's findings in parallel clinical tests. In addition, Erickson adeptly finds supplemental applications in phases of psychotherapy with promising advantage over status quo methods.

To summarize some of the more important findings: (i) An alteration in the sense of time occurs spontaneously in a majority of hypnotic subjects when a moderately deep trance can be produced. (ii) The operator, by hypnotic suggestion, can control and alter the subject's time sense to effect a speeding up of mental activity commensurate with the suggested time, and what would ordinarily consume minutes is accomplished in seconds. (iii) The experiences under distorted time are felt as real and occur with continuity. (iv) Recall of material from the unconscious can be more easily obtained.

Erickson demonstrates the psychiatric application in illustrative case material. Indications are presented that further enlightenment into all psychological functioning, including thought and learning, could be obtained by reviewing them with the time-distortion approach.

The Cooper-Erickson book is worth the attention of everyone working in the field of hypnosis for its present utility and as a basis for continued research.

ARTHUR KUHNER
Cleveland, Ohio

A Treatise on Electricity and Magnetism. vols. I and II James Clerk Maxwell. Dover, New York, 1954. An unabridged republication of the last, 3rd rev. ed. (1891). vol. I, xxxii + 506 pp.; vol. II xxiv + 500 pp. Illus. + plates. $4.95.

REPUBLICATION of Maxwell's classical treatise at a price that brings it within reach of almost any physicist interested in the history of his science is a commendable undertaking on the part of the publisher.

One cannot help being awed by the depth of perception needed to perfect the classical theory of the electromagnetic field almost singlehandedly. Maxwell had available for his starting point (i) the experimental researches and the qualitative pictorialization of Faraday; (ii) the theories of electricity of the dominant (largely German) school, which were based on the Newtonian concept of action at a distance; and (iii) Hamilton's theory of quaternions, which provided a rather esoteric basis for vector and tensor calculus.

A 30-page introduction to vector and tensor calculus includes not only the classification of vectors into "forces" and "fluxes" (corresponding to ordinary vectors and pseudovectors in current terminology) but also a discussion of the principal integral theorems required, the remark that the line integrals are appropriate to "forces" and the surface integrals to "fluxes," and a discussion of multivalued potentials (in "cyclic regions"). Quite obviously, a symbol for partial differentiation was not yet available, although the del-symbol was. It is striking how much the whole discussion appeals to one's intuition. Lines and tubes of force are introduced

immediately in this preliminary mathematical chapter.

The treatise proper is divided into four principal parts: "Electrostatics," "Electrokinematics," "Magnetism," and "Electromagnetism." In the first part, Maxwell describes with great care the contemporary knowledge of electrostatic phenomena, including such topics as dielectric breakdown and thermoelectric effect; he gives a thorough exposition of the theory of harmonic functions and ends with a chapter on instrumentation. The second part is devoted to electric currents, more particularly to direct currents. The discussion includes again both the phenomena, such as electrolysis (including its atomistic interpretation), and the theory, both of d-c networks and of three-dimensional current in heterogeneous (that is, inhomogeneous) and anisotropic media; even the nonconservative flux due to Hall effect is included.

Part III is a relatively brief (137 pages) account of magnetism, with the remaining 356 pages devoted to electromagnetic phenomena and their interpretation. The first account of electromagnetic interaction was published by Oersted in 1820. The first edition of Maxwell's treatise is dated 1873. In these 53 years the discovery of an isolated "curious" effect had led to the complete reformulation of the concepts and mathematics surounding electricity and magnetism. Maxwell deals first with those inductive phenomena that might be termed quasi-stationary in that they do not require the introduction of electromagnetic waves.

Maxwell's great invention, the displacement current, is introduced as follows. First, it is observed that in the presence of a line current the integral of the magnetic field strength, taken along a closed curve about the current, equals this current multiplied by 4π. This result is then extended to distributed currents, with the result that the electric field must be the curl of the current density. By explicit calculation, Maxwell finds then that the divergence of the current density must vanish. But this result shows, according to Maxwell, that the "true" current must be the sum of the "conduction current" (our ordinary current) and the time rate of change of the electric displacement D. This discussion represents a curious mixture of mathematical reasoning and appeal to physical intuition, which would impress us as extremely awkward if we did not remember that Maxwell presented a completely novel proposition, and that some of the mathematical awkwardness reflects not so much his ignorance of more elegant methods but the ignorance of his readers. As a matter of fact, toward the end of this discussion he summarizes most of the vector relationships in "quaternion" notation, which differs but slightly from contemporary vector notation.

In the remainder of the book, Maxwell presents not only his famous electromagnetic theory of light but also a complete discussion of the energy and stress relationships in the electromagnetic field. Truly an awe-inspiring accomplishment for one man. In a concluding chapter, he offers a critique of then current theories employing action at a distance.

I do not believe that anybody would recommend this treatise as the principal textbook for a course on electrodynamics today. As collateral reading, however, the book commends itself by the great lucidity of the textual material. The beautiful tracings of various systems of lines of force in the plates will impress the modern reader. As a historical document, as well as a source of inspiration, Maxwell's book must be ranked with the very greatest scientific writings of history.

PETER G. BERGMANN

Department of Physics, Syracuse University

The Deaf and Their Problems. A study in special education. Kenneth W. Hodgson. Philosophical Library, New York, 1954. xx + 364 pp. $6.

THE historical evolution of Western man's attitudes toward the deaf, particularly as they are reflected by his creation of arrangements and systems for their education, constitutes the hard core of this book.

Part one is a rather superficial treatment of the anatomy, physiology, and pathology of the auditory system including methods of measuring hearing loss. Part two covers the period from ancient and medieval times through the 19th century. Part three deals with "the problems of the deaf in the 20th century." There is an insightful preface by Richard Paget, authority on speech, in which he makes a plea for experimental work with his new sign language.

The author suggests that the reader may skip part one. It could just as well have been omitted because it is irrelevant to the main theme and the naive reader is likely to be confused by the attempt to verbalize complex structural relations without illustration. There are inaccuracies too, such as the statement that the A.M.A. system for calculating "the percentage of significance for intelligibility" was "arrived at experimentally."

The look back over the centuries is an interesting, although not significantly useful, elaboration and enhancement of similar material presented by Thomas Arnold, to whom the author expresses his indebtedness. How the education of the deaf was influenced by the impact of broad European philosophical, scientific, political, and social movements on education in general—the account is liberally interspersed with names like Descartes, Locke, Comenius, Pestalozzi, and Froebel—may help to break down the parochialism that still characterizes some practices in the education of the deaf.

The oral-silent issue is perspectively drawn but not without some subjective, perhaps unintentional, clouding of its delineation. Results are sometimes attributed to the personality, diligence, and skill of a teacher. And we may be unwittingly influenced by the comments on influential figures, for example, on Heinicke, oral advocate, "his overbearing conceit and rudeness" and on de l'Epee, silent advocate, "his soul rode high above the storms of earth, serene in the high peace of God."

The final section on problems is focused mainly on Great Britain and Hodgson's countrymen are urged to take note of "lavish" support of "deaf education" in America to which he attributes good results.

The objective implied in the title would have been achieved more effectively if relatively more space had been devoted to an interpretation of the empirical and experimental literature of the 20th century. Had this been done Hodgson would not have said (p. 227) "Today there is less enthusiasm for the scientific study of speech" compared with the days of Mueller and Bell.

The book rightly pleads for research on unsettled issues. If out of it grows one solid experiment it will have been worthwhile.

S. RICHARD SILVERMAN
Central Institute for the Deaf and
Department of Audiology, Washington University

Sex in Microorganisms. A symposium presented on 30 Dec. 1951 at the Philadelphia meeting of AAAS. D. H. Wenrich, Ivey F. Lewis, and John R. Raper, Ed. Committee. AAAS, Washington, D.C., 1954. v + 362 pp. Illus. $5.75 (Members, $5).

THE study of sex in higher organisms—the mechanism of union of gametes, sex-determination, development, and differentiation—has played a key role in modern genetics, embryology, and physiology. Comparable studies on microorganisms should be as fruitful, or more so, since the variety of sexual conditions in them stands in marked contrast to the relatively stereotyped conditions in higher organisms. The accomplishments to date are chiefly the discovery and description of the varied sexual systems themselves, the use of sexuality as a tool in genetic studies, an analysis of the physiology and development of sexual processes, and a general theory of sexuality (Hartmann).

Presumably, *Sex in Microorganisms* is not intended as a comprehensive, unified treatment of the field. It is a symposium by specialists representing different groups of microorganisms. Some important microorganisms and subjects are not presented at all; others receive grossly disproportionate treatment. A large part of this book is valuable in the same way that a very good classified telephone directory is valuable: you can find the names of the creatures and a listing of what they have to offer in the way of sexual capacities and capers. Raper transcends this, however; he presents a broad synthesis that is designed to reveal the opportunities for experimental work provided by the rich variety of sexual patterns in the Fungi. In the final chapter, Wenrich tries to synthesize the upshot of the whole book, but he concludes, in essence, that a satisfactory synthesis of such varied information cannot yet be achieved.

This failure is caused not merely by the great variety of sexual patterns but partly by confusion of meaning as to what sex is and partly by uncertainty as to the bearing of some of the facts on sex. Some of the authors equate sexuality with genetic recombination; others with a haploid-diploid cycle involving union of reduced nuclei; others with the existence of characteristics interpreted as male and female; others with mechanisms for bringing about mating between monoecious or hermaphroditic organisms. At this stage of knowledge there is no serious objection to putting such diverse things together in a book, but the reader needs to be aware of the differences.

The same reserve is desirable with regard to the sexual interpretations of the facts in some chapters. For example, Visconti's succinct, judicious, and restrained account of the T viruses of the bacterium, *Escherichia coli* culminates in the recently suggested hypothesis that the viruses in one bacterial cell undergo about five orgies of mating in the 20 minutes between their entrance and exit. Visconti does not urge that the facts of genetic recombination require the interpretation of mating. Conceivably, they might be due to intracellular transduction of genetic material from one virus particle to another. Again, the similarly brilliant work on genetic recombinations in the bacteria *E. coli* and *Salmonella*, in the chapter by Lederberg and Tatum, involves features that may or may not be comparable to conventional notions of sexuality, according to what one considers conventional. Doubts also exist with respect to the relationship of mating types in *Paramecium* to sexuality; this is dealt with in two excellent chapters by Nanney and by Metz. In all these instances, however, there is some relationship to sexuality, however defined, at least insofar as functions and consequences are concerned.

With regard to the quality of the chapters by the different authors, the book is as heterogeneous in this respect as it is in respect to the organisms and the points of view. I find Lewin's chapter on unicellular Algae biased, erroneous in details, and unduly circumscribed, with references to much important and well-established work omitted. On the other hand, Metz' chapter on the physiology of fertilization, although necessarily delimited in scope, is richly thoughtful and provocative, a genuinely original contribution. As for me, I would not be without a copy of the book on my desk. But my special interests lie in that direction. For others, interested particularly in sexuality and genetics or in viruses, bacteria, fungi, diatoms, unicellular Algae, or the Protozoa, the book can be strongly recommended as a rich source of information, on the whole well summarized and laid out. But for the general reader, only a few chapters will perhaps be appropriate.

T. M. SONNEBORN
Zoology Department, Indiana University

The Hidden Life of Flowers. Trans. from the French text of J. M. Guilcher. Photographs by R. H. Noailles. Philosophical Library, New York, 1954. 93 pp. Illus. $4.75.

THIS small book presents an intriguing photographic essay on the reproduction of flowering plants. It is well named, for it reveals with startling clarity the minute and microscopic flower parts that are usually familiar only to botanists. The enlarged photogravures, pictorial as well as instructive, mark R. H. Noailles as a photographer of painstaking capability and ingenuity. The explanations that accompany the pictures are brief and simple but adequate to make the intricate

steps of the transformation from bud to flower, to fruit and seeds, understandable to the layman.

These steps of the complicated changes are well organized. Both the scientist and the uninitiated should be fascinated by the pictorial progression from the simple poppy flower, with stamens and pistil developing simultaneously, to the corn flower, with male and female flowers; and from unadorned wind-pollinated flowers to the complexity of some insect-pollinated flowers. The succession is so well worked out, with instructive captions and notes, that one is reminded of the revelation of slow-motion picture projection.

The relationship of the photographed object to actual size is noted in each case. Sectioned ovaries with their translucent ovules magnified 15 times are amazing to those who have not viewed them with a hand lens or a binocular microscope, while the enlargement of pollen grains by 1080 times shows detailed structure to the scientist. It is laudible that in a popular appeal for understanding reproduction in flowers there is an almost complete absence of teleology, of ascribing purposes to the remarkable relationships that are noted.

This beautiful book could well be a required visual aid for high-school and college biology students. It ought to find its way into the libraries of flower enthusiasts and scientists alike.

HARRIET G. BARCLAY
Department of Botany, University of Tulsa

The Human Animal. Weston LaBarre. Univ. of Chicago Press, Chicago, 1954. xv + 372 pp. Illus. $6.

WESTON LaBarre has given us a remarkable book. His is an attempt to integrate the basic findings of biology, the social sciences, and psychoanalysis. On top of these disciplines, he has utilized something that many scholars have failed to heed, namely, common sense. He has succeeded very well.

Beginning with the development of early forms of life, the book goes on to the primates that lived in the trees and the bigger anthropoids that gradually developed terrestrial habits. The remainder, from Chapter IV on, is a discussion of man from the physical through cultural to psychological. The last chapter is less precise, being a summation of LaBarre's philosophic views of future development of man in general. Throughout, the author has shown deep insight, sound reasoning, and a wide reading knowledge in all the fields he deals with.

The author's position on the difference and the relationship between the psychotic and the normal is hard to agree with. He thinks that qualitatively "there is no discernible difference in content between a culture and a psychosis," and that "the only objective or operational criterion is quantitative: the number of their respective communicants" (p. 246). It is impossible to deal effectively with such a question here, but suffice it to say that most psychotics are so completely incoherent and are so unable to relate themselves to a single soul it is difficult to see what LaBarre is talking about.

A final comment is not so much a criticism as it is a sort of disappointment. Throughout, LaBarre has liberally illustrated statements with facts from many different societies, but he has been sparing with materials of the society of which he is a part except in a general way. This is especially obvious when it comes to particular items of behavior which may carry an unfavorable connotation. For example (p. 243), he states that all cultures are full of fraudulent sparganosis cures and useless baggages and that we have many examples of social organizations that separate, rather than unite, men, and religions that hamper, rather than enhance, our seeking for truth. I wonder why such things have been exemplified only by the behavior of the Dinka, the Polynesians, the Kwakiutl, or the Hindus but not by that of modern Americans.

None of these comments perilously challenges LaBarre's basic contribution to the science of man. The book is as easy to read as it is important to read.

FRANCIS L. K. HSU
Department of Anthropology, Northwestern University

Henri Poincaré: Critic of Crisis. Reflections on his *Universe of Discourse.* Tobias Dantzig. Scribner's, New York–London, 1954. xi + 149 pp. $3.

THE revolutionary changes in the picture of the physical world that took place in our 20th century were preceded (around 1900) by a new, thorough investigation of the logical structure of science. At the turn of the century, the main representatives of this "constructive criticism", were Ernest Mach and Henri Poincaré. The general opinion of 19th-century scientists was that "classical" (that is, Newtonian) physics would play the role of a "perennial philosophy" of nature that would be the legitimate successor of Aristotelian and Thomistic philosophy, but Poincaré showed with great lucidity that this opinion was based on unwarranted assumptions. This philosophic bombardment weakened the position of Newtonian science and became the opening wedge that spearheaded the assult of the new 20th-century physics of men like Einstein and Bohr. This important aspect of the crisis has not, even now, been investigated and presented very thoroughly. The present book is one of the very few that have attempted to outline the role played by Poincaré in this crisis.

Tobias Dantzig, a prominent mathematician with a keen philosophic mind, has the background adequate for this task. He describes by what arguments Poincaré raised objections to the belief in the perennial validity of classical physics and, at the same time, outlined the logical structure of any future form of physics. The author raises the question of whether he should discuss Poincaré from the viewpoint of present-day (20th century) knowledge or from Poincaré's own (19th century) knowledge of science. He decided to write, "to use a musical idiom, 'variations on themes of Poincaré.'" These "variations" consist exactly in adding to the presentation of Poincaré's own philosophy of science those connotations that emphasize the link with the future, with 20th-century theories, with relativity, and, to a certain degree, with quantum theory.

The book also provides a biographical sketch and attempts an analysis of Poincaré's personality. The wide range of these variations on themes of Poincaré can be seen from the titles of some chapters; "The iconoclast"; "The mechanistic conquest"; "In quest of the absolute, or rigid, standards"; "On clocks and signals"; "The infinite"; and "Science and reality." In the last chapter the author stresses Poincaré's view that science does not present a picture of reality but, rather, a universe of discourse by means of which we can understand and handle the realities that face us in our experience.

PHILIPP FRANK
Institute for the Unity of Science

Asia, East by South. A cultural geography. J. E. Spencer. Wiley, New York; Chapman & Hall, London, 1954. x + 453 pp. Illus. $8.50.

THE theme of Spencer's stimulating volume on southern and eastern Asia is that the many distinctive cultures of the continent have evolved in particular environments, with differences that grew out of regional variations. This is a volume on cultural geography, one that stresses people and history. It is not an encyclopedia of facts; rather it presents the reflections of a geographer who has spent several years in various parts of the Orient.

The first half of the book deals with the area as a whole, from Pakistan to Japan. Thirteen chapters consider the the usual items of the physical and human background, with considerable attention given to people, settlement, and history. The second part devotes 15 chapters to the various countries. Southeast Asia receives the major attention. A final section deals with statistics and bibliography.

Spencer writes with the sympathetic touch of a long-time resident in Asia and a skilled geographer. Here one will find an analysis of rice production in Java, the grasslands of Mongolia, and the food problems of Mother India. *Asia, East by South* contains a wealth of ideas on historical evolution and cultural characteristics. It at once takes its place as a standard addition to the literature.

GEORGE B. CRESSEY
Department of Geography, Syracuse University

Classification of Insects. Charles T. Brues, A. L. Melander, and Frank M. Carpenter. Bull. No. 108, Museum of Comparative Zoology, Harvard Univ. Cambridge, rev. ed., 1954. v + 917 pp. Illus. $9.

SOMETHING new has been added! Frank M. Carpenter, Agassiz professor of zoology and curator of fossil insects, has joined the well-known team of entomologists and teachers, Brues and Melander, in producing a new edition of the *Classification of Insects.*

A precursor was published by the two senior authors in 1915 and followed by a greatly enlarged edition in 1932. Putting the new volume beside the 1932 edition, one wants to exclaim, "How entomology has grown!" There are an additional 245 pages and an increase of 105 figures.

The preface to the first edition has been reprinted. There is a Conspectus of the Higher Groups of Insecta, followed by a key to the classes of Arthropoda, and a key to the order of insects. With each order and family is included an extensive bibliography. In the treatment of families there are many dichotomic keys to the larvae, nymphs, and pupae, as well as to the mature forms, and in some cases, as in termites, there are keys to the sexual forms as well as the workers. C. L. Remington has entirely revised the keys to the families of the Lepidoptera, both adults and larvae.

The book is much more comprehensive than its title indicates. After the insects are treated and classified, comes an important chapter on other terrestrial arthropods: Crustacea, Arachnida, Diplopoda, Chilopoda, and the others. There is a chapter on the 64 orders of extinct insects, with keys to the families and a table of geologic periods.

There is an index of 72 pages, a glossary of special terms, and an index of the common nontechnical names generally accepted.

In the past 30 years, more than 100,000 separate publications on insects have been published. Considering this, one realizes that the authors have done a monumental task. I showed a copy to a well known entomologist who, glancing at the part devoted to his specialty, reviewed the book with one sentence: "Why, it's all here!"

Classification of Insects, prepared by three experienced teachers and taxonomists, assisted by able colleagues and artists, is a classic, and an indispensable reference book to students of the land arthropods.

W. M. MANN
National Zoological Park

American Game Birds of Field and Forest. Their habits, ecology and management. Frank C. Edminster. Scribner's, New York, 1954. xx + 490 pp. Illus. + plates. $12.50.

IT is most refreshing and encouraging to find a game-management book so very much more than just that, one that avoids the word *vermin,* declares "that predation is not only natural but necessary" and that no general "antivermin" campaign is of benefit to the prey species, and states that such are a waste of time, effort, and money, and harmful to boot, although local thinning out of certain few kinds of predators may at times be helpful.

This is an admirably comprehensive, well-organized work on 18 species of our upland game birds "of most significance in sport"—the pheasant, turkey, four grouse, five quail, two introduced partridges, woodcock, and three pigeons. Chapters of usually between 20 and 60 pages are devoted to most species. The comprehensiveness is indicated by headings in most chapters on origin and classification, history, geographic range, habitat, description, importance as game, habits, shelter requirements, food, effects of climate, predation, dis-

eases and parasites, man's influence, populations, and management. There are many subheads, as, under management, land use and habitat development, stocking, protection and harvest, predator control, refuges, and so forth. Display, nesting, brood period, fall and winter activities, and adaptability are described in detail.

The plates are excellent photographs of birds, habitats, and nests. The figures are chiefly maps of geographic range and charts of food. The tables include many "life equations" showing how, despite heavy losses from climate, predators, accidents, and shooting, the birds can maintain their numbers or increase. The chief factors limiting population are climate and habitat. To increase the population we must improve the habitat. Edminster tells us how. Such improvement is in line with better land use of farms and forests.

Anyone interested in natural history would, I believe, enjoy reading this book straight through and would acquire much knowledge thereby. The ornithologist will find a wealth of biological information. For state game commissions, shooting clubs, and such, the volume is a must for constant use.

CHARLES H. ROGERS

Princeton Museum of Zoology, Princeton University

The Wilderness World of John Muir. Edwin Way Teale, Ed. Houghton Mifflin, Boston, 1954. xx + 332 pp. Illus. $4.50.

NOT long ago a colleague who works with the minutiae of cellular biochemistry came in exhilarated from a long pack trip in the high Sierras, first made famous by John Muir. He had taken a proper antidote for scientific myopia, increasingly an occupational hazard as the student of life becomes more and more absorbed in exacting details.

As such antidote, the writings of Muir himself are superb, and Edwin Way Teale has made a discriminating selection from them. In addition to the general introduction, there is a brief and helpful preface to each chapter. The illustrations by Henry B. Kane are of such distinction as to make the book a collector's item, apart from the value of its text.

The sections into which the book is divided are roughly chronological and also topical. They begin with the stern Scottish boyhood, removal to Wisconsin, and four almost unbelievable years in the great university of that state. Then comes the famous 1000-mile walk through the South, the revelation of the western mountains and their exploration, accounts of the forests, the glaciers, and finally a luminous view of Muir's personal philosophy. Interspersed are descriptions of animal life, two of which, "The water ouzel" and "The Douglas squirrel," are classic, while "Stickeen" remains one of the great dog stories of all time.

The critics are inclined to carp at Muir's heavy use of adjectives. But there are times when language has to be strained to the utmost, and the more one reads of Muir, the more one is inclined to feel that the limitations are as much those of our mother tongue as of the user. In similar fashion, the scientist might object, on superficial reading, to what the semanticists call colored words. But any suspicion of stupid teleology should vanish with deeper probing, especially into the final chapter.

There could be no more critical test of scientific integrity than John Muir's magnificent description of a forest fire. Muir loved trees and hated waste, but he knew from his own observations that fire had been, through countless centuries, an integral part of forest history. Not a word is dissipated in sentimentality, yet this clinical, almost photographic description of a great fire among the great trees is alive with the deep emotion of an observer who profoundly understands what he sees. Muir was both scientist and artist, without violence to the jealous canons of either discipline.

PAUL B. SEARS

Conservation Program, Yale University

Erratum. In the issue of March 1955, page 205, the prices of *Atomic Energy: A Survey*, J. Rotblat, Ed. (Taylor & Francis, London), were incorrectly given. They are cloth, 6s. 6d; paper, 4s. 6d.

Books Reviewed in SCIENCE

4 March

Mathematical Thinking in the Social Sciences, Paul F. Lazarsfeld, Ed. (Free Press). Reviewed by M. W. Riley.

Active Networks, Vincent C. Rideout (Prentice-Hall). Reviewed by J. Rothstein.

Cellulose and Cellulose Derivatives, pt. I, Emil Ott, Harold M. Spurlin, and Mildred W. Grafflin, Eds. (Interscience). Reviewed by G. A. Richter.

Chemical Specificity in Biological Interactions, Frank R. N. Gurd, Ed. (Academic Press). Reviewed by R. C. Corley.

Organic Peroxides, Arthur V. Tobolsky and Robert B. Mesrobian (Interscience). Reviewed by E. R. Lang.

Biochemistry of Cancer, Jesse P. Greenstein (Academic Press). Reviewed by C. P. Rhoads.

11 March

The Fundamentals of Electric Log Interpretation, M. R. J. Wylie (Academic Press). Reviewed by E. Mencher.

Los Trigos de la Ceres Hispánica de Lagasca y Clemente, Ricardo Tellez Molina and Manuel Alonso Peña (Instituto Nacional de Investigaciones Agronomicas). Reviewed by G. A. Llano.

Progress in Metal Physics, vol. 5, Bruce Chalmers and R. King, Eds. (Interscience). Reviewed by J. E. Hilliard.

Modern Experiments in Telepathy, S. G. Soal and F. Bateman (Yale Univ. Press). Reviewed by W. O. Ramsey.

Complex Variable Theory and Transform Calculus, N. W. McLachlan (Cambridge Univ. Press). Reviewed by R. M. Foster.

The Coalfields of Great Britain, Arthur Trueman, Ed. (Arnold; St. Martin's Press). Reviewed by G. D. Creelman.

Endokrinologische Psychiatrie, M. Bleuler (Thieme). Reviewed by A. Reissner.

Diagnosis and Treatment of the Acute Phase of Poliomyelitis and Its Complications, Albert G. Power, Ed. (Williams & Wilkins). Reviewed by J. P. Utz.

Television, V. K. Zworykin and G. A. Morton (Wiley; Chapman & Hall). Reviewed by D. C. Livingston.

18 March

Effects of Electricity on Muscular Motion, Luigi Galvani (Burndy Library). Reviewed by W. R. Amberson.

The Distribution and Abundance of Animals, H. G. Andrewartha and L. C. Birch (Univ. of Chicago Press). Reviewed by P. L. Errington.

Entire Functions, Ralph Philip Boas, Jr. vol. V of *Pure and Applied Mathematics,* Paul A. Smith and Samuel Eilenberg, Eds. (Academic Press). Reviewed by M. Heins.

Progress in the Chemistry of Organic Natural Products, vol. 10, L. Zechmeister, Ed. (Springer). Reviewed by Henry Feuer.

The Language of Taxonomy, John R. Gregg (Columbia Univ. Press). Reviewed by R. E. Blackwelder.

Recent Progress in Hormone Research, vol. X, Gregory Pincus, Ed. (Academic Press). Reviewed by H. Selye.

Traité de Génétique. vol. I, *Le Mécanisme de l'hérédité. Genetique formelle;* vol. II, *La Génétique des populations.* Ph. L'Heritier (Presses Universitaires de France). Reviewed by N. H. Horowitz.

Analytic Geometry, Edward S. Smith, Meyer Salkover, and Howard K. Justice (Wiley; Chapman & Hall). Reviewed by J. A. Cooley.

Heterocyclic Compounds with Indole and Carbazole Systems, Ward C. Sumpter and F. M. Miller. vol. VIII of *The Chemistry of Heterocyclic Compounds,* Arnold Weissberger, Ed. (Interscience). Reviewed by A. H. Blatt.

25 March

Successful Commercial Chemical Development, H. M. Corley, Ed. (Wiley; Chapman & Hall). Reviewed by L. F. Marek.

Animal Cytology and Evolution, M. J. D. White (Cambridge Univ. Press). Reviewed by K. W. Cooper.

Life on Other Worlds, Harold Spencer Jones (English Universities Press). Reviewed by F. B. Wood.

Quantum Mechanics, P. Mandl (Academic Press; Butterworths.) Reviewed by E. E. Salpeter.

Characteristics and Applications of Resistance Strain Gages. (National Bureau of Standards). Reviewed by G. L. Kehl.

Physical Chemistry, A. J. Rutgers (Interscience). Reviewed by J. Braunstein.

Highway Engineering, Laurence I. Hewes and Clarkson H. Oglesby (Wiley; Chapman & Hall). Reviewed by A. B. Cleaves.

Clinical Aspects of the Autonomic Nervous System, L. A. Gillilan (Little, Brown). Reviewed by A. Rosenblueth.

Rural Electrification, vols. I and II, United Nations Economic and Social Council (Columbia Univ. Press). Reviewed by C. A. Robinson, Jr.

Reports on Progress in Physics, vol. XVII, A. C. Stickland, Exec. Ed. (Physical Society). Reviewed by K. Lark-Horovitz.

The Identification of Organic Compounds, Stig Veibel (Gad). Reviewed by F. Berliner.

New Books

Thoreau: A Century of Criticism. Walter Harding, Ed. Southern Methodist Univ. Press, Dallas, Tex., 1954. 205 pp. $3.75.

Recent Developments in Cell Physiology. Proceedings of the 7th Symposium of the Colston Research Society held in the University of Bristol, Mar. 29–April 1, 1954. J. A. Kitching, Ed. vol. VII of the Colston Papers. Academic Press. New York; Butterworths, London, 1954. 206 pp. $6.50.

A Policy for Skilled Manpower. National Manpower Council. A statement by the Council with facts and issues prepared by the research staff. Columbia Univ. Press, New York, 1954. 299 pp. $4.50.

The Design and Analysis of Industrial Experiments. Owen L. Davies, Ed. Oliver and Boyd, London–Edinburgh; Hafner, New York, 1954. 636 pp. $10.

Fluorine Chemistry. vol. II. J. H. Simons, Ed. Academic Press, New York, 1954. 565 pp. $13.50.

Human Physiology. Bernardo A. Houssay, Juan T. Lewis, Oscar Orías, Eduardo Braun-Menéndez, Enrique Hug, Virgilio G. Foglia, and Luis F. LeLoir. Trans. by Juan T. Lewis and Olive T. Lewis. McGraw-Hill, New York–London, ed. 2, 1955. 1177 pp. $12.

Minerals in World Industry. Walter H. Voskuil. McGraw-Hill, New York–London, 1955. 324 pp. $5.75.

Enzymologie. Eine Darstellung für Chemiker, Biologen und Mediziner. Otto Hoffmann-Ostenhof. Springer, Vienna, 1954. 772 pp. $26.65.

Excavations at Star Carr. An early Mesolithic site at Seamer near Scarborough, Yorkshire. J. G. D. Clark. With chapters by D. Walker and H. Godwin; F. C. Fraser and J. E. King. Cambridge Univ. Press, New York, 1955. 200 pp. $11.50.

Bibliography on Physical Electronics. Prepared by Wayne B. Nottingham. Research Lab. of Electronics, M.I.T., Cambridge, Mass., 1954 (Distr. by Addison-Wesley, Cambridge, Mass.). 428 pp. $8.50.

Radioisotope Conference, 1954. vol. I, *Medical and Physiological Applications;* vol. II, *Physical Sciences and Industrial Applications.* Proc. of the second conference, Oxford, 19–23 July. J. E. Johnston, Ed. Academic Press, New York; Butterworths, London, 1954. vol. I, 418 pp., $10.80; vol. II, 223 pp., $7.50. Set, $16.

Cellular Metabolism and Infections. Symposium No. 8 of the section on microbiology held at New York Acad. of Medicine 4–5 Mar. 1954. E. Racker, Ed. Academic Press, New York, 1954. 196 pp. $4.80.

Perspectives and Horizons in Microbiology. A symposium. Selman A. Waksman, Ed. Rutgers Univ. Press, New Brunswick, N. J., 1955. 220 pp. $3.50.

A Treatise on the Integral Calculus. With applications, examples and problems. vols. I and II. Joseph Edwards. Chelsea, New York, 1954 (Published by Macmillan, New York, 1921). vol. I, 907 pp.; vol. II, 980 pp. $6.50 the volume.

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